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THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE, TRINIDAD, B.W.I.

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THE NEW SESSION 1935-36.

At the commencement of the new College year the Principal, in his opening address to the staff and students, referred to certain matters of general interest which may briefly be recorded here. After alluding to the efficient way in which the work of the College had been carried on during the long vacation when several members of the staff were away on leave, mention was made of the changes that had taken place in the personnel during the past year. Whilst the College has been fortunate in retaining the services of the professorial staff, certain of the lecturers and junior staff have left on promotion or transfer. Such changes are inevitable and are to be expected; it may be considered as one of the legitimate functions of this College to fill vacancies in other parts of the Empire with members of the staff who, after several years residence in Trinidad, have become specially fitted for promotion. The opportunities that are afforded by work at the College both for the prosecution of research and for the accumulation of experience in other directions are excellent and it is gratifying to note that members of the staff have not only made the most of these opportunities but also that their services are apparently beginning to be in demand elsewhere. The scope for promotion and transfer in the tropics is not so great as in Great Britain or the Dominions where a large number of institutions of this type have been established, because the Imperial College of Tropical Agriculture is the only one of its kind in the British tropical Empire. It is true that there are other institutions undertaking agricultural research in the tropics and that we have been glad from time to time to have been in a position to supply occasional recruits to such bodies as the Rubber Research Institute of Malaya, the Tea Research Institute of Ceylon, the Empire Cotton Growing Corporation and Imperial Chemical Industries. But they are few in number and the vacancies that occur are naturally not frequent. It is obvious, therefore, that the main openings for members of the College staff must, for some time to come, lie with the agricultural departments of the various tropical colonies. It is satisfactory to note therefore that this position has been realized by the Colonial Office and that members of our staff are now being considered for vacancies in the Colonial Service. It is clear that the College cannot afford to pay its officers more than a certain salary and that it will be necessary to release them for work elsewhere as suitable

vacancies occur after they have completed a few years service at the College. Although this arrangement undoubtedly causes a certain amount of dislocation and inconvenience, more especially in the research activities of the College, yet on the whole it is a good way out of the difficulty. If our officers can obtain suitable positions in other parts of the world after a few years at the College it is an indication that the opportunities offered by the College for experience and training in research are considerable and it will mean that there should be little difficulty in attracting a good type of recruit to fill our own vacancies from the Universities or elsewhere.

As instancing the close co-operation that now exists between the Colonial Office and this College, it may be recorded that during the past year Mr. C. C. Skeete, who was Assistant Director of Agriculture in Barbados, has been seconded from the Colonial Service for a period, to the College as Assistant Commissioner of Agriculture in the vacancy caused by the appointment of Mr. A. K. Briant to the Colonial Service as Superintendent of Agriculture, St. Vincent. Dr. F. J. Pound, the Cacao Research Botanist has been appointed to the Colonial Service as Agronomist to the Trinidad Department of Agriculture. To replace him, arrangements have been made with the consent of the Government of Nigeria for Mr. O. J. Voelcker to be seconded to the College for two years. Mr. Voelcker was a post-graduate student at the College in 1927-28, and has been engaged on cacao work in Nigeria for several years past. Other examples of close contact with the Colonial Office may be mentioned in the case of Mr. A. Pickles who has been posted as Government Entomologist to the Trinidad Department of Agriculture, and of Mr. D. Vesey FitzGerald who has received an appointment in the Seychelles to conduct an enquiry into the control of coconut-scale insects. It is true that these two officers were not actually on the College staff, being in the employ of the Trinidad Sugar Cane Investigation Committee, but both are ex-students of the College and both have been pursuing their investigations at the College laboratories. Similarly, Mr. P. E. Turner, who was seconded from the College staff to the same Committee some years ago, has now been transferred to the staff of the Trinidad Agricultural Department as Agricultural Chemist. An extension of this system of transfer and exchange is advocated and it is hoped that it will be found possible in future to include senior members of the staff as well as the juniors who have chiefly benefited hitherto.

Other changes that have taken place in the staff, include the retirement on 31st August of Mr. F. W. Urich from the post of Assistant Professor of Entomology. Mr. Urich is a man with a wide international reputation possessing an unrivalled knowledge of the Caribbean fauna. The Governing Body has expressed its great appreciation of his services and has ordered that all laboratory facilities should be afforded him to enable him to continue his investigations after his retirement. The post of junior lecturer in entomology has now been reconstituted and it is to be filled by Mr. R. G. Fennah. Another retirement is that of Mr. E. E. Pyke whose contract under the Cacao Research Scheme came to an end in August and who has now obtained a research post on the staff of the Royal College of Science in London. During the vacation, a new post—namely that of Student Demonstrator—was sanctioned by the Governing Body. This was necessitated partly by the fact that the College Farm has been increased considerably in extent during the last few years, and also that the lecture and demonstration hours are proving somewhat too long for the present staff of this department to manage.

The Principal stated that practically all last year's post-graduate students had secured appointments in the Colonial Service. This would seem to be an indication that the Crown Colonies, as a whole are now beginning to recover from the disastrous slump of 1931 and it is to be hoped that it will be found feasible again to send a larger number of Colonial Office scholars to the College than has been possible during the last three years. With regard to the Diplomates several of them had been able to obtain suitable employment on private estates and elsewhere. It was pointed out that this was bound to be the main outlet for the employment of diploma students since appointments by the Caribbean Agricultural Departments although almost invariably reserved for men who had passed through the College, were comparatively few in number and regular vacancies each year could not therefore be guaranteed.

Reference was made to the research activities of the College. The position with regard to the Cacao Research Scheme is that it is at present being conducted for another year on the old basis. The Governing Body has decided, however, that this research should be continued as one of the normal activities of the College and that the research officers should therefore be absorbed in the cadres of the Botany and Chemistry Departments of the College. This principle has also been confirmed by the Colonial Agricultural Advisory Council who commended the scheme at a recent meeting and meted out praise for the nature of the results already achieved in the five years that have elapsed since the inception of the Research. As matters stand at present it is proposed to continue the scheme for a further five years from September 1936 and a revised programme covering this period has been submitted and approved. The funds have been provided in the past by contributions from the cacao producing colonies on the one hand and certain of the chocolate manufacturers of Great Britain on the other. There is now good prospect that the necessary funds will be forthcoming to continue the research for another five years from the same sources.

The position of the Low Temperature Research is somewhat different as the nature of the work is such that it would be difficult to incorporate it into the regular departments of the

College. Funds were provided in the first instance by the Empire Marketing Board but since this body ceased to function, the provision of the necessary finance has annually presented a serious difficulty, although by means of grants from the Colonial Development Fund the research has been kept going on a reduced scale and on a year to year basis. In spite of these circumstances so adverse to long range research, the results that have been achieved have won considerable recognition, and the advice of the Station is being continually sought from commercial sources as well as in scientific circles. It was recently the subject of a unanimous resolution which was passed at the session of the Imperial Botanical Conference which was held in London last August, when tribute was paid to the work already accomplished and attention was drawn to the urgent need for adequate financial support to enable it to carry on its activities. It is earnestly hoped that funds will be found to enable it to continue to function, as apart from other less mercenary reasons much capital has already been sunk in buildings and equipment.

In conclusion the Principal referred to certain academic distinctions that had been gained during the year by two members of the staff and congratulated Mr. D. W. Duthie, the Lecturer in Chemistry, and Mr. F. J. Pound, the Cacao Research Botanist, on obtaining the Ph.D. degree. Such successes are not only gratifying to the Institution itself but also to the individuals concerned as well as to the heads of the departments with whom they have been associated in research work.

G. E.

THE NEW TEEID LIZARD OF TRINIDAD.

By H. W. Parker,
Dept. of Zoology, British Museum (Natural History).

A year ago, when preparing a list of the Lizards of Trinidad, the author noted that during the preceding 40 years only a single new species had been discovered on the island. Strangely enough another species was found almost immediately afterwards, two examples being taken by two different collectors. I have pleasure in naming this new form after Mr. Benjamin Shreve of the Museum of Comparative Zoology, Harvard, who has so courteously placed the second specimen at my disposal, knowing it to represent an undescribed form. Acknowledgments are also gratefully made to Mr. D. Vesey-Fitzgerald, through whose interest and generosity the British Museum has received so many valuable Neotropical reptiles and amphibians.

Proctoporus (Oreosaurus) shrevei sp.n.

Holotype a female, number 1935.8.31.1 in the British Museum from the Heaths of the Aripo Northern Range, Trinidad; collected by D. Vesey-Fitzgerald in April, 1935.

Head rather short. Fronto-nasal once and a quarter as long as broad; no prae-frontals; frontal pentagonal, a little shorter and narrower than the fronto-nasal; interparietal much larger than either the fronto-parietals or the parietals, and followed by a pair of enlarged occipitals which form a median suture. Four supra-oculars; no loreal, the nasal shield more than twice as long as deep; two prae-, three post-, and three sub-oculars. Three upper labials in front of the centre-line of the eye; upper temporals enlarged; a single median, and three pairs, of chin shields, of which the first two pairs make contact; chin shields followed by three chrevon-shaped rows of larger scales which are separated from the free edge of the collar by eight straight transverse rows of scales. Dorsal scales feebly sub-imbricate, elongate hexagonal, strongly keeled, in 38 transverse rows between the occipitals and the base of the tail; 15 or 16 dorsal scales transversely at the middle of the body, separated from the ventrals by a lateral zone six scales wide; laterals half the size of the dorsals; ventrals juxtaposed, quadrangular, in regular transverse and longitudinal series at the middle of the body, the outermost being very much smaller than the others; 19 transverse rows between the collar fold and the pre-anals. Thirty-five scales round the middle of the body. Scales of the tail quadrangular, narrower above than below, smooth, except dorsally at the base where they grade into the dorsals. Hind-limb reaching the wrist of the adpressed fore-limb. No femoral pores (♀).

Brown above with small indistinct flecks which are most numerous on the tail; a series of lighter, but indefinite, oval spots forms an ill-defined dorso-lateral, light streak from the eye to above the shoulder. A dark, oblique, narrowly white-edged bar from below the eye to the edge of the upper lip. Lower surfaces uniform white; edge of lower jaw brownish, with four white bars on each side.

The paratype, number 38659 in the M.C.Z., Harvard, is a juvenile collected in Trinidad by Mr. N. A. Weber. It agrees in essentials of pholidosis with the type. There are eight gulars between the post-mental groove and the edge of the collar, eight longitudinal rows of ventrals (though the outermost rows are so small that one might almost count only six), 38 dorsals from the occiput to the base of the tail, and 33 scales about the middle of the body. The colour, too, is similar to that of the type, but the rows of dorso-lateral light spots are more distinct and extend to the tail, and the sides of the neck, head, flanks and limbs have a few small, circular, ocellar, white spots irregularly scattered over them.

	Type.	*Paratype.*
Length ..	134 mm.	(Tail incomplete)
Head	11 do.	7 mm.
Width of head ..	6 do.	4 do.
Snout to vent ..	47 do.	23.5 do.
Fore-limb ..	12 do.	6.5 do.
Hind-limb ..	19 do.	9.5 do.
Tail	84 do.	?

This species is apparently most closely allied to the Colombian *P. striatus* (Peters). It differs in the different arrangement of the gulars, the less numerous transverse rows of ventrils, broader zone of laterals, fewer suboculars and immaculate belly.

AGRICULTURE IN NIGERIA.*

By O. T. Faulkner, C.M.G.
Director of Agriculture, Nigeria.

An Agricultural Department in a country like Nigeria should always be working for the next generation as well as the present; and to refer only to the past would be to mention only half its work. For instance, there are several interesting lines of work which it is not yet possible to say for certain whether they will eventually prove successful or not, and there are others which are, humanly speaking, absolutely certain to be of great value to the country in 20 years' time.

The history of most of the lines of work of the Agricultural Department dates only from 1921, when the Department was practically re-created after its almost complete dispersal and suspension during the War. From then, till about 1928, little was attempted beyond investigation, experiments and trials on Government farms—preliminary measures which are essential before any work can be started among the people themselves. For, before the small peasant is asked to try out any new method or idea, the Agricultural Officer must first have studied it practically and investigated it most thoroughly himself; and, so far as is humanly possible, he must have made absolutely certain that the peasant can adopt it successfully, and that it will pay him to do so. In most parts of the country, and in most of our lines of work, it was thus only in 1928 that we were able to start real "extension work" among the farmers of the country. Now it is always the case that such work proceeds very slowly and with many difficulties and disappointments for several years, then a turning point is reached, and suddenly progress instead of being slow and halting becomes easy and rapid; it almost seems to come of its own accord; everything seems suddenly to conspire for success instead of for difficulty and delay. A superstitious person could almost imagine that seven is a mystic number for this Department. For in 1914 the small Agricultural Department of that time went into a state of suspended animation; in 1921 it came to life again; in 1928, it ceased to be occupied mainly with experiments on its own farms and started its main function of extension work among the farmers; and there seems little doubt that this year will mark the turning point between slow, plodding, laborious extension and rapid progress.

During the last twenty-five years the agricultural exports of Nigeria have increased roughly as follows:—Cocoa, twenty-fold; cotton, ten-fold; ground-nuts, two hundred-fold; benniseed, forty-fold; palm kernels, 50 per cent., and palm oil 50 per cent. Thus the new, strictly agricultural crops have increased many fold, while in the same time the older industry of collecting the fruit of wild palm trees has only increased by 50 per cent.

If the values are considered, the picture is much the same; the annual value of the palm products exported 25 years ago was about £4,000,000; that of the new agricultural crops about £200,000. He would be a bold man who put down any exact figure at what the palm products of Nigeria are likely to be valued in 1935, but it is reasonable to hope that they will bring in £5,000,000 to £6,000,000. The new crops, on the other hand, are bringing in fully £4,000,000 a year, even in these bad times, as against the £200,000 of 1910.

The obvious deduction from these figures is not misleading. The collection of wild products, like those of the shea-nut tree, of the wild rubber vine and even of the wild oil palm, is really a relic of the past—it is the cultivated crops that have a future. If the palm industry is to survive, the palm must become a crop.

At the same time, it will hardly be necessary to tell the readers of this *Review* that the great change that has occurred does not mean that the people have changed over from producing palm oil and kernels to cultivating crops—it merely means that in 1910, the only part of the country which was effectively opened up to trade was the part near the coast which is tapped by the numerous creeks and rivers, and which produces palm oil and kernels, and little else that is exportable. Since that date, the hinterland has been opened up by roads and railways, and new export commodities have been found which can be produced in those drier parts, further from the coast, where the palm does not flourish. It is of interest to note that it is, even yet, only parts—though admittedly most of the richest parts—which can yet be said to be opened up to trade. The whole of the country has been covered with a network of roads. But even to-day, in spite of the railway construction of the last decade, fully one-half of the country, and probably fully one-third of the people, are too remote from any railway station, port or river to be able to export agricultural produce even if they have a road. There is still room for much increase of agricultural production merely by the bringing of more of the people of the country "on to the map" of production for export. There is even more opportunity to increase the production for export of those who already contribute to the trade of the country.

* Reprinted from the *West African Review*, Vol. VI, No. 93, June, 1935, by the kind permission of the Editor and of the Author.

In the matter of the production of palm oil and kernels the Department has already been able to induce a sprinkling of native farmers to begin making plantations of planted palms. They are mostly very small plantations of one or two acres each: only a few rich men have several acres each. But the plantations are good: they are little inferior to those of Sumatra and Malaya, except in point of size. An acre of planted palms, reasonably tended, as they are generally being tended in Nigeria, yields two or three times as much fruit as an acre of wild palms, and the fruit can for many years be harvested with a fraction of the labour, since the planted oil palm, unlike the wild one, bears fruit for many years before it is so tall that harvesting entails climbing up the tree. Great opposition was encountered to this measure when it was first proposed to the natives of the country—active opposition, not mere passive resistance. It was only when the palms, planted by the Department on its own farms for experiment and demonstration, first began to fruit in about 1928 that we were able to get the first few farmers to let us help them to make plantations on their own land. By the end of 1933, some 380 farmers had planted just over 1,000 acres; by the end of 1934 the totals were about 700 planters and 1,600 acres. Progress in 1934 was greatly retarded by the terribly low prices then obtainable for oil and kernels; but now that the price has risen again, applications for instruction in planting are being received in much greater numbers than ever before, and it seems reasonable to hope that 1935 will be the turning point, and the beginning of really rapid extension.

A method of extraction of palm oil by the use of a small press was worked out after several years of investigation. The new method yields seldom less than 50 per cent. and sometimes nearly 100 per cent. more oil than can be extracted by the native method from the same quantity of fruit; and the press-extracted oil is of best edible quality. Progress, as with all such introductions, has been slow at first, and the low prices of oil in the last two years have greatly handicapped the work. By the end of 1934, nearly 100 presses had been bought and were in regular use by native extractors, but in the first two months of 1935 almost as many presses were sold or ordered as in the whole of 1934, and there is every reason to anticipate better progress now.

Great importance is attached to these two matters, for the Nigerian farmer who has a small palm plantation and is able to get his oil extracted in a press will be in a position to face the period of intense competition between African and Sumatran palm oil, which it seems must come in the near future. If he relies on collecting fruit from wild palms and extracting the oil by inefficient, wasteful methods, the small African producer cannot hope to compete for ever with the planted palms and big extracting factories of the East. But if the African can use substantially the same technical methods as the Eastern planter, then against the lesser efficiency resulting from the small scale of his operations he can set the advantages that the peasant proprietor has over the big employer of paid labourers; and he should thus be able to hold his own in the struggle. It is largely a race against time: can the African peasant be induced and helped to adopt modern methods before it is too late? A year or two ago it looked as though the answer would be "No"; by the end of this year we hope it will look distinctly more likely to be "Yes".

The expansion that has occurred in cotton-growing in Nigeria is almost entirely due to the introduction of American cotton in the Northern Provinces by the Agricultural Department, and to the operations of the Department in distributing seed and supervising grading and marketing. The commercial export of American cotton produced by native farmers in the Northern Provinces began in 1915-16 with 121 bales; in 1934-35 the export was over 49,000 bales. In 1935, if the weather is satisfactory, it is expected to increase further. The native cotton of the Oyo and Abeokuta Provinces has also been replaced by a cotton of superior quality and equal hardiness, the Improved Ishan, a strain bred locally by the plant breeders of the Department. The introduction of this cotton unfortunately only just preceded the beginning of the depression, and progress has been greatly retarded in consequence, so that the export of 1932-33 was only 860 bales, 1933-34 2,900 bales, and that of 1934-35 is not expected to exceed 4,500 or 5,000 bales. However, steady progress is being made now. The ordinary indigenous cottons of Nigeria, both North and South, are of such inferior quality that they are only exportable in periods of exceptionally high prices. There is no doubt that, but for the work of the Agricultural Department in introducing better varieties of cotton, the total export in the season 1934-35, instead of being nearly 60,000 bales, would not have been as much as 10,000.

In regard to cocoa, the operations of the Department have been mainly concerned with improving the quality of the product. In 1922, Nigerian cocoa, as exported, could not truthfully be called cocoa—some other name should have been used for the mouldy, weevily, grubby, unfermented brown beans that were regularly shipped. To-day, thanks to the system of produce inspection and the educative work of the Department, the quality of the product exported compares favourably with any in the world in its freedom from damage by mould and insects; a considerable part of the crop is now well fermented; and though there is still room for improvement in the matter of fermentation, the proportion of properly fermented cocoa is, on the whole, steadily rising. It may be mentioned here, in passing, that all kernels and oil for export from Nigeria are also

inspected and are only permitted to be shipped if they are up to the trade standards of purity—standards which were seldom attained before the inspection system was introduced.

Bulk marketing of first-quality cocoa produced by small growers has been introduced and gradually brought on to the lines of real co-operation by self-managing, self-supporting societies. The figures of the numbers of members and of the quantities sold are not perhaps as yet very impressive. In the season 1934-35, some 6,300 members sold about 2,200 tons of cocoa through the co-operative societies, as against 1,608 tons sold in 1933-34 by 4,877 members. But the rate of growth of co-operation has not been forced at all in Nigeria and the objective throughout has been soundness, both technical and financial, rather than quantity. Consequently, though the plant is yet small, it is a very healthy seedling and it is growing steadily. The organisation of the societies has been greatly improved in 1934-35, and it is already clear that this will have a marked effect during the present year.

The increase of the production of benniseed which has occurred in recent years is largely due to the efforts of the Agricultural Department in teaching the Tiv people how to grow the crop properly, after it had itself learnt to do so by experiment. There is still room for much improvement in this matter; for, owing to his bad methods, especially his failure to weed the crop at all, the ordinary grower obtains only about one-quarter of the yield that the Agricultural Officer gets on the Native Administration farm. The increase of the export of this crop is hindered by the absence of competition in its purchase; but, in spite of that, continued increase is practically certain in the next few years.

The export of peeled, sun-bleached ginger from Nigeria is a small trade, whose existence is wholly due to the efforts of the Agricultural Department, and which is rapidly growing. Export was started, after a few years' experiments and preliminary work, in 1930-31 with 15 tons. In 1932-33 the figure was 53 tons, in 1933-34 86 tons, and 1934-35 over 200 tons. The product is of excellent quality, and the crop is all graded and bought under close supervision by the Agricultural Officers. Again continued increase is practically certain.

The most important work of the Department, however, is one which does not yet appreciably affect the trade figures. This is the introduction of mixed farming in the Northern Provinces—that is ploughing with cattle, manure-making with the use of bedding, the keeping of cows, and the rearing of calves. Given a pair of bullocks, a family in Northern Nigeria can grow 12 to 16 acres of crop (according to the part of the country in which it is living) instead of the three to five acres that they can cultivate by hand; and, thanks to the remarkably great effect of even a little farmyard manure, and to the more frequent weeding that is possible when cattle are used, the mixed farmer gets much better crops in each of his 12 or 16 acres than he got before on each of the three or four-acre plots. In 1934, some of the mixed farmers had incomes of as much as £12, as against the £3 or so of the hand-hoe farmer. Owing to their lack of capital, every man who wishes to start has to obtain a loan of about £5 from his Native Administration, repayable over a period of four years, to cover the cost of the bullocks and implements with which he is supplied. A start was made in 1928 with three men; by the end of 1933, the number farming on this system was 173; in 1934, 299; and in 1935 the number will be very little short of 600. Now the greater part of each of the ordinary small farms worked by hand is necessarily devoted to growing the farmer's own food. The mixed farmer needs to put no more land under food crops than does the man with the hand-hoe, for he can feed his cattle on the by-products of the farm, without growing any crops specially for cattle food. Thus each mixed farmer produces three or four times as much for export, both of groundnuts and cotton, as does his neighbour who uses only his own hands. It will be realised that when there are even a few thousand mixed farmers, not to mention a few hundreds of thousands, it will make a great difference to the exports of the Northern Provinces of Nigeria.

There could not be a better example of the wisdom of thorough preliminary experiments than is afforded by this work. Between 1924, when the great possibilities of mixed farming were first realised, and 1928, when three ordinary farmers were asked to give the system a trial, five years was spent in working out the proposed system most fully and in making sure that it was entirely feasible and sound. Of the first three men who started, one had by the end of 1930 proved moderately successful and one not completely unsuccessful, while one had failed completely. For three years, from 1928 to 1930, our efforts to introduce the new system had had the most discouraging results: farmer after farmer started on the new system and failed in a year or two. Had not the experiments on our own farms given us complete faith in our new system of farming there would then have seemed to be little justification for continuing our efforts to introduce it among farmers. Thanks to that confidence we could keep on, in spite of many disappointments, until we have now passed the turning point. There is now no doubt whatever that we have succeeded in starting an agricultural revolution, which in time will bring the wealth of Northern Nigeria on to an altogether different level of prosperity from that of the past.

FOR SALE.

"NATURE TEACHING" by Sir Francis Watts. 6th Edition 1934, price 3*s*. 6*d*. Obtainable from: The Secretary, West India Committee, 14, Trinity Square, London E.C.3., England.

FIELD TECHNIQUE WITH THE PLOUGH.

By D. D. Paterson, B.Sc.
(*Imperial College of Tropical Agriculture*)

Introductory.

All over the tropical world to-day, the primitive native wooden plough is being ousted by the more durable and more efficient steel plough of modern design. Implement manufacturers of Europe and America have at last begun to realise that, in the tropics, there is a large and ready market for cultural implements of correct specification. Travelling salesmen are being sent out to establish agencies, study local conditions and advise headquarters regarding the types of implement most suited to the needs of any particular community. In accordance with their instructions, new models are designed, tested and, if satisfactory, exported to the cultivators for whom they have been constructed. In consequence, the tropical farmer has now a very wide selection of cultural implements to choose from, varying in type from the simple pole plough for ox draught, to the multiple disc type requiring high-powered mechanical traction.

The native wooden plough is in the nature of a single tine cultivator, which will only operate in fairly soft soil, stirring it to a depth of from four to six inches. It works its way through the surface soil more or less as the prow of a ship forces its way through the water, and the soil is thrown up equally on either side of the point or share. The field practice, when this plough is used, is therefore very simple. The ploughman starts at one side and ploughs backwards and forwards along the length of the field, each new furrow being cut on the land immediately adjoining the furrow made on the way down. A strip of soil some nine inches wide and six inches deep is therefore indifferently well cultivated each trip, the closer the furrows are together the more thorough the cultivation. An alternative practice occasionally used in small or irregular patches of ground is to cultivate round and round, generally working from the outside inwards to the centre. [Fig. I (1) and Fig. I (2)].

While either of these practices is eminently successful with a simple wooden plough, the structure of the modern plough is such as to necessitate a somewhat more elaborate technique in the field. The plough is constructed not merely as a soil stirrer but also as a soil inverter. It cuts a furrow slice, roughly rectangular in cross section, raises and inverts it, with a consequent lateral displacement of the soil of a few inches. With the exception of a few special models, all ploughs are constructed with a share and mouldboard (or their equivalent in the form of a disc) which, depending on the original specification, will either invert the soil to the right or to the left of the direction of travel. It is not normally possible to transform a right-hand plough into a left-hand one or *vice versa*. This makes it impracticable in ploughing to return up the field alongside the furrow that has just been cut on the way down, as then the second furrow slice would be turned away from the ploughed soil on to the unploughed land leaving some of the subsoil exposed. [Fig. I (3)].

Furthermore in order to be certain of inverting all the soil to the same depth, to minimise the draught, and obtain the maximum cultural benefit from the operation, the furrows should run straight and parallel to one another. It is gradually being realised by the native cultivator that while the steel plough is an undoubted improvement on the home-made implement of his forefathers, it does entail the abandonment of his previous haphazard *modus operandi* in favour of a better planned field practice. Where the older customs still prevail, it will often be found that the reason is not lack of willingness to adopt the new methods but rather lack of knowledge of the correct procedure. As with most field practices there are many different ways of achieving the same result, depending on the particular environmental conditions. This article describes in detail some simple ploughing systems which experience has shown to be thoroughly efficient and at the same time, once a field demonstration has been carried out, well within the comprehension of the native farmer or the semi-illiterate mechanic of the tropical zone.

Ploughing with Animal Draught.

In most fields, it is not possible to carry the furrows right up to the boundaries on account of walls, hedges, ditches, &c. The first operation in good ploughing is to mark off the HEADLANDS, which are merely small areas of land left at the ends of the field to give the animals room to turn in with the plough running empty. The furrows will normally be made along the length of the field, and, as a result, the headlands are taken off the ends of the field. With a two-animal yoke, a strip 15 feet wide will suffice, but with larger teams, the headlands will have to be made up to 30 feet in width. They are generally demarcated by cutting a shallow furrow slice at the required distance from the boundary, the soil being turned towards the outside of the field so as to leave a clearly defined furrow wall as a guide to the ploughman. The headlands are ploughed across after the rest of the field has been completed. [Fig. II (1)].

For ease of description, let us assume that, in all the following examples, a plough with a right-hand mould board or disc—*i.e.*, one which turns the soil to the right of the direction of travel—is used. The simplest method of all is to start in the centre of the field and plough backwards and forwards, along and around the median line

turning in a clockwise direction at the ends, with the plough running empty. If this is done, the second furrow C D is thrown up against the first furrow A B [Fig. II (1)] and so on with successive journeys as shown in the cross section diagram of the furrows. To begin with, the ploughman returns almost on his own tracks, but as the area of ploughed land gets larger, the amount of running empty that he has to do at the ends increases proportionately. Thus, to complete the last two furrows, E F and G H, he has to walk the whole width of the field. This method is therefore only practicable when the field is in the form of a long narrow strip, not exceeding, say, 100 feet in width.

With larger fields, the same general procedure can be followed, with the single modification that the field should be divided into suitable sized sections or LANDS, and each section treated as a separate ploughing unit. Working on this system, the units should be made from 30 feet to 50 feet in width, a figure being chosen which will divide exactly into the width of the field. As with the headlands, the lands may be located by pegs put in at the requisite intervals, but are best marked on the ground with a plough, the resultant furrows being termed the FEERINGS. The first feering should be cut half the width of the land from the boundary, so that, if the width of the field is an exact multiple of that of the land, the last feering will be similarly placed with relation to the other side. If the land is not chosen so as to divide equally into the width of the field, there will be a strip of unploughed soil left on the east of the field after the routine ploughing has been completed. This odd section would then have to be treated as a third "headland".

Starting once again at A, [Fig. II (2)] ploughing proceeds as before, in a clockwise direction gradually working outwards from the first furrow A B until the edge of the field is reached. The ploughman then moves over to the next feering C D and carries out the same operation for that unit until he makes contact with the land already ploughed at *x y*. By repeating this process for the other lands E F, G H, &c., the whole field can be completed, and the maximum distance which the plough will have to travel empty across the ends will be limited to the width of the land, *i.e.*, not exceeding 50 feet.

An interesting feature of this process is that, at the midpoint between the feerings, *i.e.*, at the centre of each land, a distinct channel—the *open furrow*—will be formed. Consider the line marked *x y* on the diagram. When ploughing the first unit the ploughman, when he reaches this point, will be travelling from *x* to *y* and, with a right-hand mould board, the soil will be inverted towards the west of the field. When ploughing the second unit, he gets once again to the *x y* location just as he is making contact between the two ploughed sections. In the second unit, however, the plough is travelling from *y* to *x*, and the soil will therefore be inverted towards the east of the field, *i.e.*, away from the last furrow of the first land, thus giving rise to the aforementioned open furrow.

Similar open furrows will be formed midway between the other feerings. They serve the useful purpose of temporary surface drains. In fact, in heavy wet soils the lands are often made much narrower—down to 20 feet apart—so as to increase the number of open furrows formed in ploughing and improve the drainage. For successive crops, it is advisable to vary the location of the open furrows by changing the position of the lands from year to year. If the same feerings were used for successive ploughings, there would be a gradual alteration of the surface contours of the field due to the accumulative effect of always turning the soil in towards the centre of each land.

The system of ploughing used in England is merely a slightly more elaborate modification of the above procedure. Headlands and lands are marked out as before, the lands generally being made 66 feet wide or thereabouts, which both practice and theory have shown to be the optimum distance. The first feering is cut one quarter land's width, *i.e.*, 16½ feet from the side boundary, and the remainder at 66 feet intervals across the field. The ploughman commences as before on the first feering, A B (Fig. III), working round in a clockwise direction until he has reached the edge of the field when a strip 33 feet wide will be completed. He then proceeds from the point (*a'*) to the second feering, and again working in a clockwise direction from the centre outwards completes a 33 feet wide strip. As the feerings are 66 feet apart, this leaves a 33 feet wide section of unploughed land between the two ploughed areas.

To plough this, having reached the point *q*, he turns anti-clockwise instead of clockwise, and ploughs down the line, *r s*, inverting the soil up against the land first ploughed. At *s*, the turn is again anti-clockwise to cut the furrow from *p* to *q*. And so the section *p q r s* is ploughed moving in an anti-clockwise cycle and working from the outside towards the centre where the open furrow *x y* will again be formed. Similarly at E F, a strip 33 feet wide is first ploughed in a clockwise direction round the feering and the turning direction is then reversed to complete the intervening unploughed section : and so on across the field. The clockwise cycle of operations, where the soil is inverted inwards over the feerings is termed in ploughing parlance GATHERING, while the reverse cycle in which the ploughman is working from the outside of the unploughed land towards the centre where the open furrow will ultimately be formed is known as SPLITTING. The reason for this alternate gathering and splitting is of course to minimise the amount of running empty at the ends. On this system with 66 feet lands, the maximum turning width between consecutive furrows is 33 feet. While

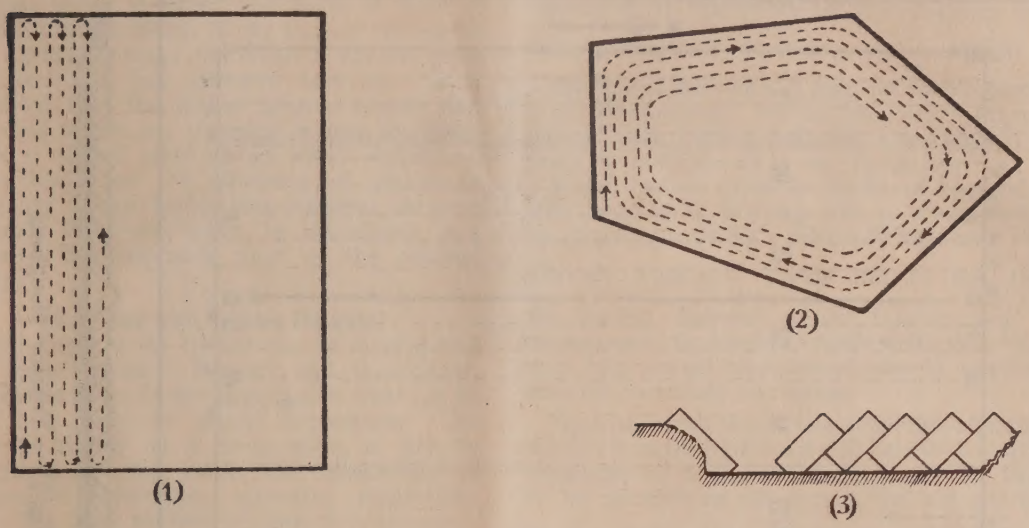

Fig. I—Primitive ploughing methods.

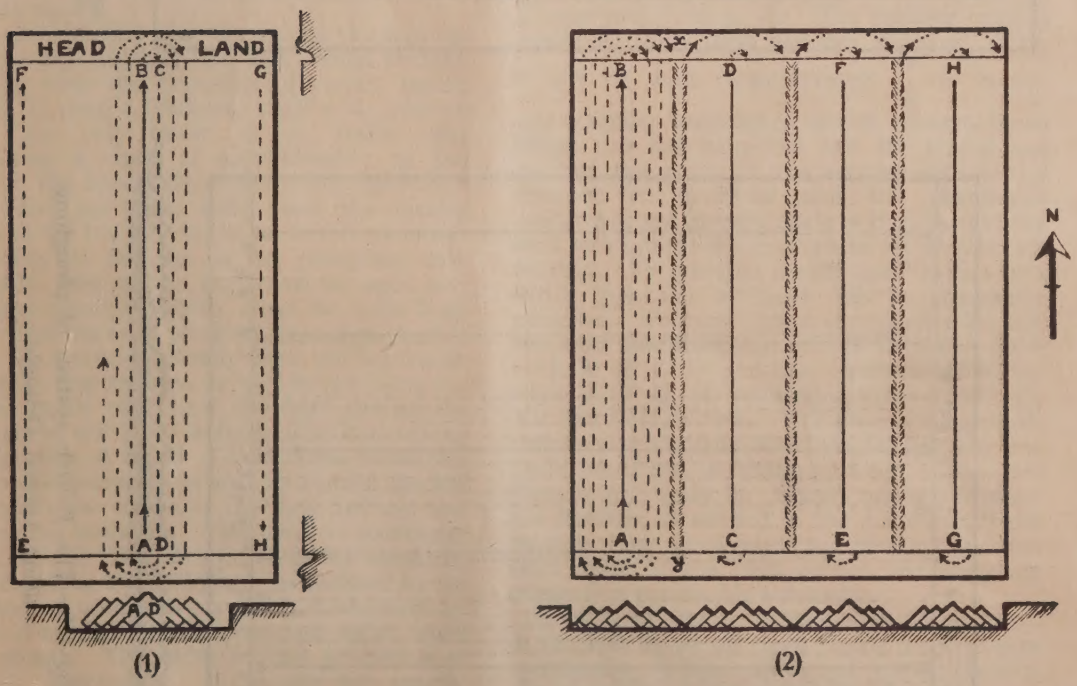

Fig. II—Simple methods of ploughing using Animal Draught.

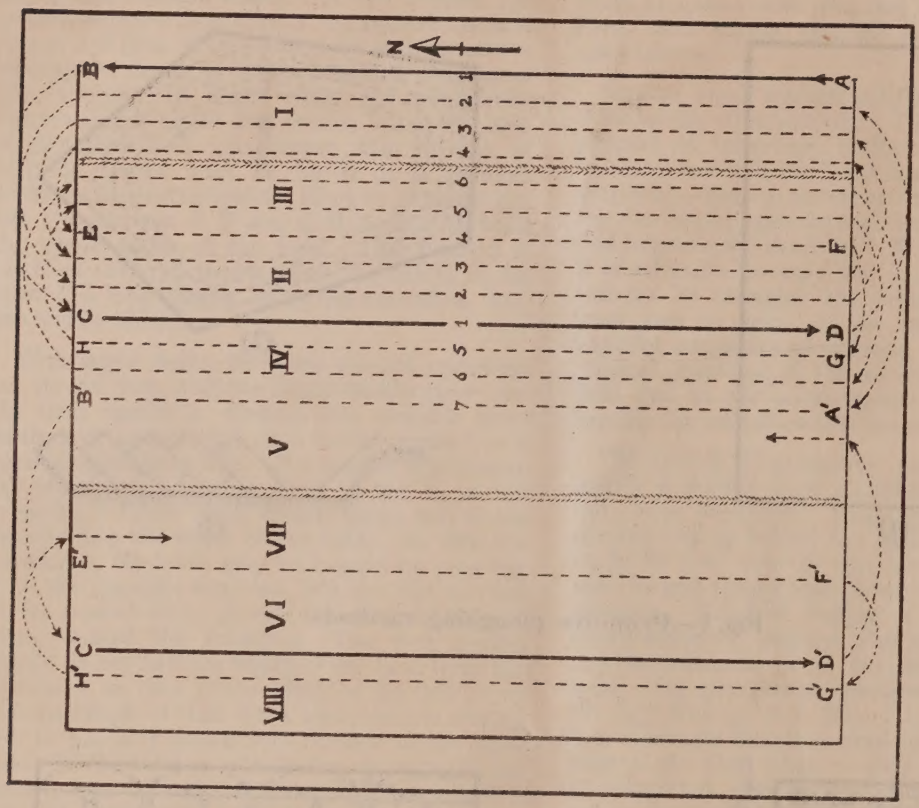

Fig. IV—Tractor ploughing

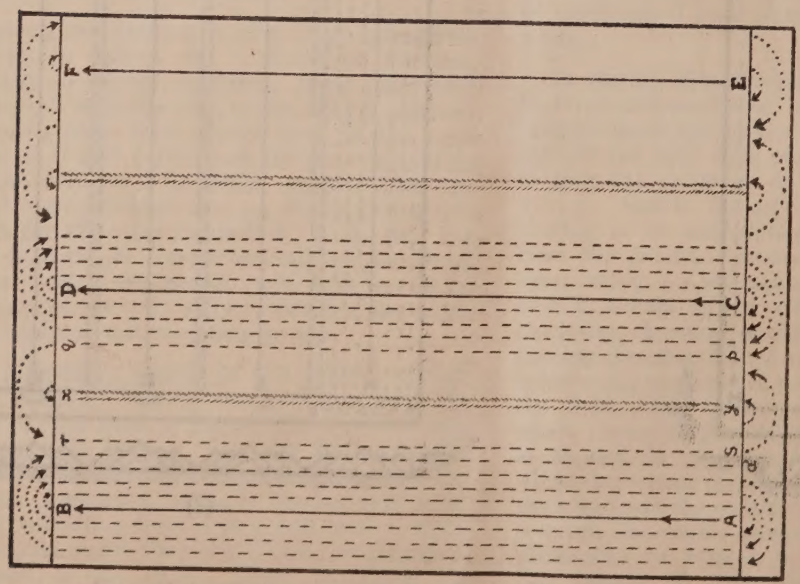

Fig. III—The British system of ploughing using Animal Draught

this technique, once it is grasped, is comparatively simple, the explanation of it to the novice often becomes rather involved and liable to lead to confusing ideas, which in the case of the native may ultimately make him revert to his own more primitive and less effective methods. It is suggested that the rather simpler system first described is the one to adopt in new localities, where it should serve as an easily understood object lesson on the efficiency of system in ploughing. Once this has been accepted, the more elaborate technique might be introduced as a modified but improved form of the original practice.

Ploughing with Tractor Draught.

Agriculture in the tropics can be divided into two main classes — Peasant and Capitalistic. Cultivation in the former is limited to what can be done with hand or animal implements. The latter is usually on a large scale, is heavily capitalised and has led to the introduction of mechanised cultivation, wherever practicable. While the most modern equipment is obtained, the actual operation of the implements in the field generally falls to the lot of the local mechanic, whose experience either as a ploughman or a driver may be somewhat meagre. Thus, where a tractor ploughing outfit is concerned, a thorough preliminary training in some appropriate field technique will often prove a definite economy in the long run.

It is not feasible with the tractor to adopt the field practice which is used with animal draught, because, with the exception of certain special models (1), even a relatively small 2- to 3-furrow outfit can only return on its tracks after completing a circle of approximately 15 feet radius. The headlands are generally made some twenty-five per cent. wider than the turning radius of the tractor—say from 20 feet to 40 feet depending on the size of the ploughing unit. Normally, they are not cut across the ends only but right round the field. After the main body of the field has been ploughed, it is then possible to use the tractor to plough round the headlands, without having to turn, the first furrow being cut on the inside edge, and the final one at the periphery of the field. In the headland ploughing the direction of travel of the tractor round the field should normally be such as to turn the soil in towards the centre of the field and not out towards the boundary. This tends to counteract erosion effects that often occur at the outskirts.

In ploughing the field proper as enclosed by the headlands, it is necessary to divide it into lands by means of feerings cut on the surface with a small pony plough. The width of land selected is of primary importance. It should be exactly divisible into the width of the field, to give a quotient which is a multiple of four. Thus, if x feet is the width of the land, and y feet of the field, $\frac{y}{x}$ should be an integer which is a multiple of four. If the width of the field is known this can be ensured by choosing a suitable size of headland. Furthermore, in order to avoid overlapping in the last circuit on any ploughing unit, the quarter-land or zone, *i.e.*, $\frac{x'}{4}$ should be a multiple of the width of strip cut by the plough in any one journey. For example, with a 3-furrow plough, with 14-inch bottoms, x feet should be made a multiple of 3 by 14 inches, *i.e.*, of 3 feet 6 inches. This is chiefly of importance with large units carrying five to seven mouldboards and ploughing a relatively wide strip each journey. Finally, $\frac{x'}{4}$ should not be less than the turning diameter of the tractor, and, in consequence, the lands are made wider than those used with animal ploughs and may be anything from 100 feet to 200 feet across.

The first feering should be located three-quarters of x feet from the right-hand side-headland, and the remainder at x feet intervals across the field. If the calculations are correct, the last one will be $\frac{x'}{4}$ from the left-hand side-headland. Assuming that a right-hand plough is being used the tractor starts at the south-east corner and, ploughs along the inside of the right-hand headland from A to B, and returns along the first feering at C D (Fig. IV). The individual circuits made by the tractor have been numbered in sequence, 1, 2, 3, &c. The opening cycle is continued until there are two ploughed strips, I and II, each approximately $\frac{x'}{4}$ in width, and a similar unploughed section between them. When this has happened and the tractor has reached the point F, the turning direction is changed to clockwise and the ploughman operates round the new circle G H E F, until the next two quarter-lands or zones III and IV are finished. By this time a strip equal to one land width from the headland will be completely ploughed. The next section is tackled in exactly the same way ploughing anti-clockwise round the circle A′ B′ C′ D′ and then clockwise round the circle E′ F′ G′ H′ completing zones V and VI, VII and VIII in turn. This process is repeated, right across the field, the ploughing in any one cycle occurring in alternate zones. The open furrows will again be located midway between the feerings, as marked in the diagram. If the feerings have been correctly planned and the start made at the right corner, the ploughing sequence is practicably automatic.

In order to simplify explanations, the diagrams in the text have all been made to represent rectangular fields, which of course, renders the ploughman's task relatively straightforward. Fields in the tropics are rarely as regular in shape as this, and some modification of the general schemes outlined then becomes necessary. In some instances, as in narrow sugar-cane beds intersected by deep drains, a special technique has to be evolved to suit the peculiar local

conditions (1). Even where the ploughing proposition appears to be straightforward, it is generally advisable before starting operations in the field, to plan exactly how the work has to be carried out. For this purpose, a rough chain survey from which a field plan with approximate dimensions can be drawn up, is exceedingly helpful, and at the same time forms a permanent reference as regards acreages, &c. The chain will also be needed to peg out the headlands and lands, so as to ensure accurate location of the feerings. Where neither chain nor tape is available, a good ploughman, provided he is certain of his field practice, will generally make a satisfactory job merely by pacing off the requisite distances of the lands in order to locate the feerings. In conclusion, therefore, let it be emphasised that the first essential of economy combined with efficiency in ploughing is a well-planned field technique.

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(1) Massy, C. R. and Paterson, D. D. "The use of the Tractor in Trinidad for Sugar Cane Cultivation." *Tropical Agriculture* X, pp. 280-85.

VEGETATIVE PROPAGATION OF COFFEE.*

THIS paper presents a concise review of the different methods employed in propagating coffee vegetatively. The advantages claimed over seedling propagation are uniformity of habit, bearing capacity, and quality of berry and bean. Disadvantages are merely of a technical nature.

METHODS.

(1) *Cutting.*—Hardwood and softwood stem cuttings both yield rooted plants under suitable conditions. Hardwood cuttings are difficult to root in the open, but success is reported for a method which uses prunings from trees grown on the multiple stem system, each cutting being about 2 ft. long by 1 to 1½ ins. diameter. Softwood cuttings are rooted in a propagator; the frames have glass lights, overhead shade, and are heated from beneath by hurricane lamps. Sand, washed and steam sterilised, is used as a rooting medium. Great importance is attached to selecting just the right type of shoot, those with a semi-hardwood base, and a softwood tip with leaves retained, giving the best results. The cuttings are 6 to 9 inches long and not more than ¼ inch diameter. The frames are kept closed to conserve a high humidity and are watered twice a week. The sand is held at temperatures between 68°F. and 72°F. Such cuttings root in three to four months. (The reviewer, using similar cuttings of *C. arabica* in a solar propagator, found rooting was also very slow. Quite a number of tropical plants exhibit a tendency thus to "go to sleep" when put in the propagator as softwood cuttings, this being particularly noticeable with those of sapodilla, which have sometimes remained a year before rooting. Occasionally, however, batches will root in a very much shorter time, which indicates the importance of inherent factors, such as the age of flush, and possibly the age of the parent tree, on quickness of rooting.) The effect of various gases on hastening root formation was tried with negative results. Root cuttings and leaf cuttings failed to propagate in all trials.

(2) *Layering.*—Both layering and marcotting gave success in preliminary trials but multiplication by these methods is slow and tedious. Quicker results were obtained by ring-barking suckers at the base of an old stumped tree, followed by etiolation. The practical technique developed from this method is as follows:—"A rooted cutting from a selected tree is planted out in a nursery at an angle of approximately 25° from the horizontal. By keeping it pegged down, it will continue to grow in this plane. As this plant grows, suckers come away from the axillary buds. When about 12 inches high they are ring-barked at the base, and soil banked round them. When rooted, the soil is removed and the sucker cut away from the parent plant which again will produce further cycles of suckers for similar treatment. In the first cycle only a few of the rooted suckers should be removed, the remainder being pegged over at right angles to the original plant to provide a larger area for the production of rooting material in the second and subsequent cycles. Experimentation has shown that earthing up must not be carried out until the suckers are ready for rooting, and even then it is necessary to ring-bark each sucker."

(3) *Budding.*—This presents several technical difficulties so is not much used. The bud union is mechanically weak and tends to break off in heavy wind.

(4) *Grafting.*—Inarching, if both seedling stocks and scions are no objection, is an easy way of grafting one coffee variety upon another. For clonal propagation considerable success is obtained with cleft grafting on to seedling stocks. As a result of considerable experimentation large stocks and scions are recommended, the stocks being 18 to 24 months old, and the scions preferably of the same diameter as the stocks. The stock is cut just above a node and a cleft two inches deep made, into which the scion, trimmed to a wedge, is inserted, bound, and waxed. The scion must have at least one bud, and two or three are preferable. For grafting on to old stocks in the field, cleft grafts on to basal suckers are recommended, the old tree being cut back either before grafting or afterwards.

The writer stresses the importance of selecting propagation material only from consistently high yielding trees.

E. E. P.

* S. Gillett in *East African Agricultural Journal*, Vol. I, 1, 1935.

RECENT INVESTIGATIONS ON SUGAR-CANE AND SUGAR-CANE SOILS IN TRINIDAD.

II—Interactions of Lime with Nitrogen, Phosphate and Potash, and with Pen Manure, in Relation to Yield of Cane.

P. E. TURNER.
Sugar Agronomist to the Department of Agriculture, Trinidad.

Introduction.

Mention is made in the first paper of this series that the presence of manures in certain combinations can seriously diminish the gain in yield which results from a dressing of ground limestone to acid soils (1). In the present paper an account is given of the effect on the immediate and residual gains in yield due to liming of the inorganic manures, sulphate of ammonia, superphosphate and sulphate of potash, when present alone and in pairs, and of the organic manure, pen manure.

The results which are described have been obtained in the main from two complex experiments, laid down in the field, which have been continued over a series of crops. By means of these experiments the existence of a number of first and second order interactions of lime with other manures has been established on a statistical basis. It is believed that certain of these interactions were hitherto unknown.

The two experiments provide many contrasts in general character, *e.g.*:

(1) They are laid down on very different soil types, in one case a swamp-and-lagoon clay, in the other case a degenerated loam.

(2) Two very dissimilar types of layout are in use. In one experiment the layout is in the form of randomised blocks, the various treatments being separated into two series in a manner such that there appear in any one block only half the total number of manurial combinations under investigation. In the other experiment the layout is in the form of Latin squares, the rows of the squares being subdivided into strips.

(3) On one experimental area, the effect of increasing dressings of nitrogen on the gain in yield resulting from a fixed dressing of ground limestone equal to the lime requirement, in the presence and absence of potash and phosphate, is under measure. On the other area the effect of a fixed dressing of nitrogen on the gain resulting from increasing dressings of ground limestone, in the presence and absence of various combinations of phosphate, potash and pen manure, is under study. The latter experiment gives information supplementary to the former, in that it enables a measured contrast of the behaviour of inorganic manures on soil with a lime status which increases regularly to a maximum in considerable excess of the lime requirement. Further, the latter experiment enables the effect of pen manure on the interaction of inorganic manures with lime to be gauged under this range of conditions.

The yield data for the two experiments give rise to principles which are in general agreement. Such agreement provides confirmatory evidence as to the validity of the various interactions of lime with other manures which are recorded, and suggests that these interactions are of wide application as far as sugar cane is concerned.

Details of the two experiments are set out below. For reasons of simplicity the results obtained for each experiment are taken in turn. The method of measurement of lime requirement in these experiments is based on the degree of unsaturation of the soil with lime (6).

Experiment III.

General Description of the Experiment.

Experiment III was laid down in 1930 on a swamp-and-lagoon clay. Details for this soil type have previously been given (1). The experimental area was planted with sugar cane of the variety B.H.10(12). It was harvested as plant canes in 1932, as first ratoons in 1933 and as second ratoons in 1934.

QUANTITIES OF MANURES USED ON PLANT CANES, FIRST RATOONS AND SECOND RATOONS.

The quantities of manures used for the three crops reaped on the experimental area are recorded in Table I.

TABLE I.—*Quantities of manures to the acre (Experiment III).*

Manure.	Index.	Plant canes.	First ratoons.	Second ratoons.
Ground limestone ..	Ca_0	Nil.	Nil.	Nil.
	Ca_1	10 tons	Nil.	Nil.
Sulphate of ammonia ..	N_0	Nil.	Nil.	Nil.
	N_1	40 lb. N	53 lb. N	53 lb. N
	N_2	80 lb. N	107 lb. N	107 lb. N
	N_3	120 lb. N	160 lb. N	160 lb. N
Superphosphate ..	P_0	Nil.	Nil.	Nil.
	P_1	150 lb. P_2O_5	150 lb. P_2O_5	150 lb. P_2O_5.
Sulphate of potash ..	K_0	Nil.	Nil.	Nil.
	K_1	150 lb. K_2O	150 lb. K_2O	150 lb. K_2O

The dressing of ground limestone of ten tons to the acre applied to the plant canes is equal the lime requirement of the soil.

The quantities of manures applied to the first ratoons are identical with those applied to the plant canes except that no limestone was added to the first ratoons and that the dressings of nitrogen were each increased by one-third. The quantities of manures applied to the second ratoons are identical with those applied to the first ratoons.

DESIGN AND LAYOUT OF EXPERIMENT III.

The dressings of lime, phosphate and potash are combined in every possible way with the four dressings of nitrogen. The 32 possible combinations thus obtained are separated into two series of 16, in a manner such that every possible combination of three treatments at a time appears once in each series of 16. The 16 combinations of the one series are scattered at random in Block IA and those of the other series in Block IB. The 32 possible combinations may be separated in this manner into two series of 16 in three alternative ways. These alternatives are used to form the six randomised blocks IA and IB, IIA and IIB, and IIIA and IIIB which are set out in the plan of the experiment (Figure I).

A layout of this design has the merit of reducing the size of the block to one-half, thereby tending to diminish the range of soil variation within the block, an important factor in view of the number of treatments and the comparatively large area of each plot (1/15 acre). The method adopted for separating into two series the total number of manurial combinations, and the use of all the

FIGURE I.—*Plan of Experiment III with yield data for the plant canes and the second ratoons.*

Block IA				Block IB.			
(18) 391 306	(24) 386 310	(27) 251 165	(15) 261 240	(22) 355 235	(23) 289 264	(17) 280 236	(13) 357 247
(1) 311 197	(9) 316 235	(12) 337 303	(4) 310 291	(31) 260 163	(28) 371 212	(16) 401 322	(30) 392 183
(14) 476 339	(6) 426 275	(26) 345 247	(32) 338 210	(3) 287 194	(11) 292 215	(5) 322 177	(2) 415 272
(21) 354 277	(19) 323 251	(29) 305 162	(7) 300 182	(20) 429 298	(10) 379 277	(25) 276 113	(8) 497 305
Block IIA.				**Block IIB.**			
(27) 360 131	(32) 421 198	(11) 301 209	(6) 399 270	(9) 262 200	(30) 388 184	(18) 413 218	(2) 463 211
(17) 430 251	(26) 446 200	(4) 431 245	(22) 457 279	(14) 409 247	(19) 316 203	(25) 286 88	(8) 464 225
(1) 379 189	(23) 390 245	(13) 423 245	(20) 449 240	(31) 369 95	(15) 324 235	(3) 337 149	(5) 387 166
(29) 399 163	(16) 479 268	(10) 445 227	(7) 335 172	(28) 406 151	(24) 415 317	(12) 452 238	(21) 382 267
Block IIIA.				**Block IIIB.**			
(23) 325 233	(29) 331 127	(9) 373 182	(27) 296 103	(19) 401 196	(25) 340 64	(10) 466 251	(21) 422 291
(2) 407 259	(12) 404 276	(17) 393 209	(14) 469 298	(24) 432 361	(31) 395 132	(1) 378 160	(4) 482 269
(3) 310 217	(20) 477 299	(5) 293 170	(32) 363 218	(18) 395 289	(16) 490 301	(28) 489 204	(13) 469 256
(8) 383 285	(22) 411 269	(26) 409 173	(15) 264 209	(7) 283 185	(30) 465 201	(6) 502 261	(11) 371 228

The top figure in each plot gives the yield of plant canes and the bottom figure the yield of the second ratoons. Yields are expressed as stones (14 lb.) per plot. The plot size is 1/15 acre. The treatment numbers are enclosed in brackets.

TABLE II.—*List of plot treatments and mean yields of cane in tons per acre.*

Plot treatments.	Mean Yields of Cane.		Plot treatments.	Mean Yields of Cane.	
	Plants. (1930-32).	Second ratoons. (1933-34).		Plants. (1930-32).	Second ratoons. (1933-34).
(1) $N_1K_0P_0Ca_0$	33.38	17.06	(17) $N_3K_0P_0Ca_0$	34.47	21.75
(2) $N_1K_0P_0Ca_1$	40.16	23.19	(18) $N_3K_0P_0Ca_1$	37.47	25.41
(3) $N_1K_0P_1Ca_0$	29.18	17.50	(19) $N_3K_0P_1Ca_0$	32.50	20.31
(4) $N_1K_0P_1Ca_1$	38.23	25.16	(20) $N_3K_0P_1Ca_1$	42.35	26.16
(5) $N_1K_1P_0Ca_0$	31.32	16.03	(21) $N_3K_1P_0Ca_0$	36.19	26.09
(6) $N_1K_1P_0Ca_1$	41.48	25.19	(22) $N_3K_1P_0Ca_1$	38.23	27.59
(7) $N_1K_1P_1Ca_0$	28.69	16.84	(23) $N_3K_1P_1Ca_0$	31.37	23.29
(8) $N_1K_1P_1Ca_1$	42.00	25.47	(24) $N_3K_1P_1Ca_1$	38.53	30.88
(9) $N_2K_0P_0Ca_0$	29.72	19.28	(25) $N_0K_0P_0Ca_0$	28.19	8.28
(10) $N_2K_0P_0Ca_1$	40.32	23.59	(26) $N_0K_0P_0Ca_1$	37.51	19.38
(11) $N_2K_0P_1Ca_0$	30.13	20.38	(27) $N_0K_0P_1Ca_0$	28.34	12.47
(12) $N_2K_0P_1Ca_1$	37.28	25.53	(28) $N_0K_0P_1Ca_1$	39.57	17.72
(13) $N_2K_1P_0Ca_0$	39.04	23.38	(29) $N_0K_1P_0Ca_0$	32.34	14.13
(14) $N_2K_1P_0Ca_1$	42.32	27.63	(30) $N_0K_1P_0Ca_1$	38.91	17.75
(15) $N_2K_1P_1Ca_0$	26.54	21.38	(31) $N_0K_1P_1Ca_0$	32.00	12.19
(16) $N_2K_1P_1Ca_1$	42.81	27.84	(32) $N_0K_1P_1Ca_1$	35.06	19.56

possible alternatives, enables the sum of squares for interactions as high as the third order to be disentangled from error, and allows a measure of their significance.

A list of the 32 plot treatments is recorded in Table II.

Summary of Yield Data for Experiment III.

The individual plot yields for the plant canes and the second ratoons (taken as representing both types of crop) are set out on the plan of the experiment (Figure I). The mean yield data for these crops are set out in Table II. The yield data for the first ratoons are incorporated in this paper when additional information is required to clarify the issues involved.

The analysis of variance of the yield data for the second ratoons is set out in an appendix to this paper (Appendix I).

Direct Effects of Lime, Nitrogen, Phosphate and Potash on Yield.

GROUND LIMESTONE.

In Experiment III the average gain in yield of plant canes due to the dressing of ground limestone is 7.95 tons to the acre. The corresponding gains in yield of the first and second ratoons, due to the residual effects of this dressing, are 6.34 and 6.10 tons to the acre, respectively. Each of these gains might be due to chance less than once in 100 times. The direct effects of limestone on yield in Experiment III are discussed in the first paper of this series (1).

SUPLHATE OF AMMONIA.

Sulphate of ammonia gave average gains in yield of the plant canes, the first ratoons and the second ratoons varying from 1.56 to 2.40 tons to the acre, 7.82 to 13.05 tons to the acre, and 5.62 to 10.00 tons to the acre, respectively, according to the size of the dressing. The gain in each crop of the series due to sulphate of ammonia might be due to chance less than once in 100 times.

SUPERPHOSPHATE.

On the average the dressing of superphosphate led to a loss in yield of plant canes of 1.65 tons to the acre, which might be due to chance less than once in 20 times. The average effect of this manure on the first ratoons and second ratoons is very small and statistically not significant.

POTASH.

The experimental area is becoming more and more deficient in potash with each successive crop. The dressing of sulphate of potash caused an average gain in yield of 1.13 tons to the acre of plant canes, an amount which might be due to chance more than once in 20 times. Potash led to an average gain in yield of 1.70 tons of first ratoons, which also is of doubtful significance. This manure caused an average gain in yield of 2.01 tons of second ratoons, which might be due to chance far less than once in 100 times. The average effect of potash on the yield of second ratoons is unimportant at dressings of nitrogen not exceeding 40 lb. to the acre. It is of importance when the dressing of nitrogen attains 80 lb. to the acre. (Appendix I.)

The direct effects of nitrogen, phosphate and potash on yield, and their interactions with manures other than lime, will be more fully discussed in later papers of this series.

Interactions of Lime with Nitrogen and Phosphate.

THE INTERACTION OF LIME WITH NITROGEN.

The effect of increasing the dressing of sulphate of ammonia on the gain in yield of plant canes and ratoons, due to lime, is recorded in Table III.

TABLE III.—*Effect of size of dressing of nitrogen on gain in yield due to lime. (The interaction of lime with nitrogen).*

YIELDS OF CANE IN TONS PER ACRE.

Plant Canes (1930-32).

Dressing of ground limestone in 1930	DRESSING OF S/A PER ACRE IN 1930.			
	Nil	40 lb. N	80 lb. N	120 lb. N
10 tons per acre	37.76	40.47	40.68	39.14
Nil	30.22	30.64	31.36	33.63
Gain due to lime	7.54	9.83	9.32	5.51

First Ratoons (1932-33).

Dressing of ground limestone in 1930	DRESSING OF S/A PER ACRE IN 1932.			
	Nil	53 lb. N	107 lb. N	160 lb. N
10 tons per acre	27.41	33.51	34.13	37.77
Nil	17.16	26.69	30.69	32.89
Gain due to lime	10.25	6.82	3.44	4.88

Second Ratoons (1933-34).

Dressing of ground limestone in 1930	DRESSING OF S/A PER ACRE in 1933.			
	Nil	53 lb. N	107 lb. N	160 lb. N
10 tons per acre	18.60	24.75	26.15	27.51
Nil	11.77	16.86	21.11	22.86
Gain due to lime	6.83	7.89	5.04	4.65

Plant Canes (1930-32).—The gain in yield of the plant canes due to the limestone is maintained at a value ranging from 7.5 to 9.8 tons of cane until the dressing of sulphate of ammonia exceeds 80 lb. of nitrogen to the acre. At the dressing of 120 lb. of nitrogen, the gain is only 5.5 tons of cane.

First and Second Ratoons (1932-33, 1933-34). The residual effects of the limestone on the yield of first ratoons and second ratoons exceed 6.8 tons of cane until the dressing of nitrogen approaches 100 lb. to the acre. At dressings of nitrogen greater than 100 lb. the effect of the limestone falls to five tons of cane or less.

The gains in yield of plant canes and ratoons, due to the dressing of ground limestone, are maintained at high levels until the dose of nitrogen exceeds a limiting value, when the gain due to liming is very considerably reduced. The limiting value for the dose of nitrogen under the conditions of Experiment III appears to lie in the region of 80 to 100 lb. to the acre. It is probably dependent on many factors including weather and soil conditions.

The diminution in gain in yield due to limestone, as the dose of nitrogen is increased, cannot be established as statistically significant for the plant canes. For the first ratoons it might be due to chance less than once in 20 times. For the second ratoons it might be due to chance less than once in 100 times. The interaction of lime with nitrogen is more clearly evident for the ratoon canes than the plant canes because of the heavier dressings of nitrogen which were applied to the ratoons. Also it is probable that with successive dressings of manures the fertility of the various plots are becoming more and more dependent on the particular nature of the individual treatments, and that uncontrolled soil variation is a factor of less importance in the yield of the ratoon crops than in the yield of the plant canes.

The graphs in Figure II afford an empirical explanation of the interaction. Curves of diminishing returns are obtained when yield of cane is plotted against size of dressing of nitrogen. In the presence of lime the curve approaches a maximum more rapidly than in the absence of lime. Consequently the distance between the two curves, which is a measure of the gain in yield due to liming, ultimately diminishes as the dressing of nitrogen is increased. Growth measurements made on the 1934-35 crop of plant canes on the plots of Experiment III show an identical interaction of lime with nitrogen (2).

Associated with the significant diminution in the gain in yield due to lime in the presence of high nitrogen there is a corresponding significant diminution in the gain in yield due to nitrogen in the presence of lime. The yield data in Table IV give a measure of this effect of lime with increasing dressings of nitrogen.

It is evident from the data in Table IV that *liming to the lime requirement can considerably reduce the gain in yield due to sulphate of ammonia.* The reduction can be significantly greater with heavy dressings of nitrogen than with light dressings.

The effect of dressings of lime in excess of the lime requirement on the gain in yield due to nitrogen is discussed later in this paper in connection with Experiment V (December*). The effect of dressings of sulphate of ammonia in excess of 160 lb. of nitrogen to the acre on calcareous soils is discussed in connection with Experiment VIII *.

* *Tropical Agriculture*, Vol. XII, No. 12.

TABLE IV.—*Effect of lime on gain in yield due to nitrogen. (The interaction of nitrogen with lime).*

GAINS IN YIELD DUE TO SULPHATE OF AMMONIA.

First Ratoons (1932-33).

Dressing of ground limestone in 1930	Dressing of S/A per Acre in 1932.		
	53 lb. N	107 lb. N	160 lb. N.
10 tons per acre	6.10	6.72	10.36
Nil	9.53	13.53	15.73
Diff. in gain in yield due to S/A	−3.43	−6.81	−5.37

(*Second Ratoons* (1933-34).

Dressing of ground limestone in 1930	Dressing of S/A per Acre in 1933.		
	53 lb. N.	107 lb. N.	160 lb. N.
10 tons per acre	6.15	7.55	8.91
Nil	5.09	9.34	11.09
Diff. in gain in yield due to S/A.	+1.06	−1.79	−2.18

TABLE V.—*Gain in yield due to lime in presence and absence of phosphate. (The interaction of lime with phosphate).*

YIELDS OF CANE IN TONS PER ACRE.

Plant Canes (1930-32).

Dressing of ground limestone in 1930.	Dressing of Superphosphate in 1930.	
	Nil	150 lb. P_2O_5 per acre.
10 tons per acre..	39.55	39.48
Nil	33.08	29.85
Gain due to lime	6.47	9.63

Second Ratoons (1933-34).

Dressing of ground limestone in 1930.	Dressing of Superphosphate in 1933.	
	Nil	150 lb. P_2O_5 per acre.
10 tons per acre..	23.71	24.79
Nil ..	18.25	18.05
Gain due to lime	5.46	6.74

THE INTERACTION OF LIME WITH PHOSPHATE.

The effect of phosphate on the immediate and residual gains in yield of plant canes and ratoons, due to the dressing of limestone, is recorded in Table V.

Plant Canes (1930-32).—The immediate gain in yield of plant canes due to the dressing of limestone in the absence of phosphate is 6.5 tons to the acre. In the presence of phosphate the gain is 9.6 tons. The difference in the gains might be due to chance about once in 100 times.

Second Ratoons (1933-34).—The residual effect of the dressing of limestone on the second ratoon canes amounts to 5.46 tons to the acre in the absence of phosphate and 6.74 tons in the presence of phosphate. The interaction of lime with phosphate in relation to the yield of second ratoons might be due to chance less than once in 20 times.

The dressing of ground limestone therefore gives rise to significantly greater gains in yield of both crops in the presence than in the absence of phosphate (Figure III).

It is noteworthy that in the presence of a dressing of lime equal to the lime requirement the effect of phosphate on the yield of plant canes is negligible. In the absence of lime, phosphate causes a significant depression in the yield of plant canes of 3.23 tons to the acre. Under certain conditions dressings of phosphate have been shown to bring about significant reductions in yield of plant canes in a number of field experiments in Trinidad. A typical example is given in Table XIX.

THE INTERACTION OF LIME WITH NITROGEN AND PHOSPHATE.

The effect of size of dressing of nitrogen on the gain in yield due to lime, in the presence and absence of phosphate is recorded in Table VI. The data make it clear that the interaction of lime with phosphate is dependent on the dose of nitrogen.

TABLE VI.—*Effect of size of dressing of nitrogen, in presence and absence of phosphate, on gain in yield due to lime. (The interaction of lime with nitrogen and phosphate.)*

GAINS IN YIELD DUE TO LIMESTONE.

Plant Canes (1930-32).

Dressing in 1930 of superphosphate	Dressing of S/A per Acre in 1930.			
	Nil	40 lb. N.	80 lb. N.	120 lb. N.
150 lb. P_2O_5 per acre	7.15	11.18	11.71	8.51
Nil	7.95	8.47	6.94	2.52
Diff. in gain in yield due to lime ..	−0.80	+2.71	+4.77	+5.99

Second Ratoons (1933-34).

Dressing in 1933 of superphosphate	Dressing of S/A per Acre in 1933.			
	Nil	53 lb. N.	107 lb. N.	160 lb. N.
150 lb. P_2O_5 per acre	6.31	8.14	5.80	6.72
Nil	7.36	7.65	4.28	2.58
Diff. in gain in yield due to lime ..	−1.05	+0.49	+1.52	+4.14

Plant Canes (1930-32).—On the plots without nitrogen the gain in yield in the presence of phosphate (7.15 tons of cane) is slightly smaller than in the absence of phosphate (7.95 tons of cane). With a dressing of 40 lb. of nitrogen to the acre the gain due to lime in the presence of phosphate exceeds by 2.71 tons of cane the gain in the absence of phosphate. With dressings of 80 lb. and 120 lb. of nitrogen the differences in the gains in yield further increase to 4.77 tons and 5.99 tons of cane, respectively, in favour of the presence of phosphate. The difference in the gain in yield due to lime, in the presence and absence of phosphate, therefore continuously increases as the dressing of nitrogen rises to 120 lb. to the acre. For the plant canes this interaction of lime with nitrogen and phosphate is on the border line of significance.

In the absence of phosphate the gain in yield of plant canes due to lime is as small as 2.52 tons to the acre on the plots dressed with 120 lb. of nitrogen. The average gain in yield of plant canes due to lime (for all plots) is 6.34 tons of cane.

Second Ratoons (1933-34).—The higher dressings of nitrogen applied to the second ratoons bring out the interaction of lime with nitrogen even more clearly. On the plots without nitrogen the gain due to lime in the presence of phosphate (6.31 tons of cane) is smaller than in the absence of phosphate (7.36 tons of cane). On the plots dressed with 40 lb. of nitrogen to the acre the gain is somewhat the larger on the plots with phosphate. As the dressing of nitrogen rises beyond this value the difference in favour of the presence of phosphate further increases to over four tons of cane. The interaction of lime with nitrogen and phosphate for the second ratoons might be due to chance far less than once in 100 times.

In the presence of phosphate the gain in yield of the ratoon canes due to lime is largely independent of the size of dressing of nitrogen. In the absence of phosphate the gain has diminished greatly at the dressing of 107 lb. of nitrogen to the acre. When the dressing of nitrogen attains 160 lb. the gain due to lime has fallen to 2.58 tons of cane. The average gain in yield of second ratoons due to lime (for all plots) is 6.10 tons of cane.

In the presence of high nitrogen, dressings of phosphate to both plant and ratoon canes appear to be essential if the gain in yield due to a dressing of lime equal to the lime requirement is to be maintained at its normal value. The effect of phosphate in the presence of smaller and larger dressings of lime is discussed later in this paper in connection with Experiment V.

The differences in gains in yield of plant and ratoon canes due to lime, in the presence and absence of phosphate, are plotted against the size of dressing of nitrogen in Figure IV. The curves approximate to straight lines.

It has been shown in Table IV that liming to the lime requirement can significantly reduce the gain in yield due to sulphate of ammonia. The reduction in yield can be counteracted by a dressing of phosphate (Table VII).

TABLE VII.—*Effect of lime in presence and absence of phosphate on gain in yield due to nitrogen. (The interaction of lime with nitrogen and phosphate.)*

AVERAGE GAINS IN YIELD DUE TO SULPHATE OF AMMONIA.

Second Ratoons (1933-34).

Dressing of ground limestone in 1930.	Dressing of Superphosphate in 1933.	
	Nil	150 lb. P_2O_5 per acre.
10 tons per acre ..	6.87	8.20
Nil	9.40	7.62
Diff. in gain in yield due to S/A.	−2.53	+0.58

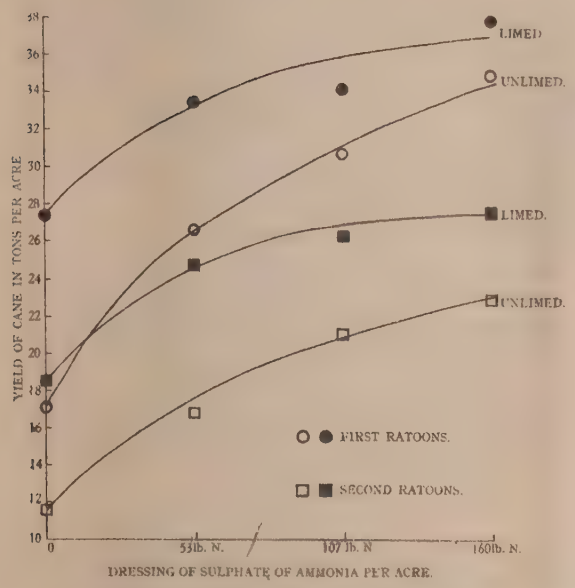

FIG. II. EFFECT OF SIZE OF DRESSING OF NITROGEN ON YIELD IN THE PRESENCE AND ABSENCE OF LIME (THE INTERACTION OF LIME WITH NITROGEN)

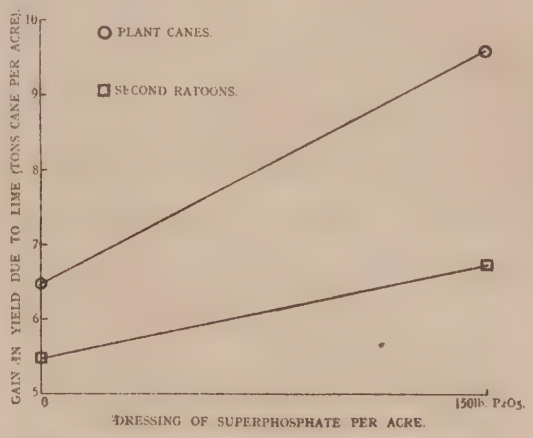

FIG. III.—EFFECT OF PHOSPHATE ON GAIN IN YIELD DUE TO LIME. (THE INTERACTION OF LIME WITH PHOSPHATE).

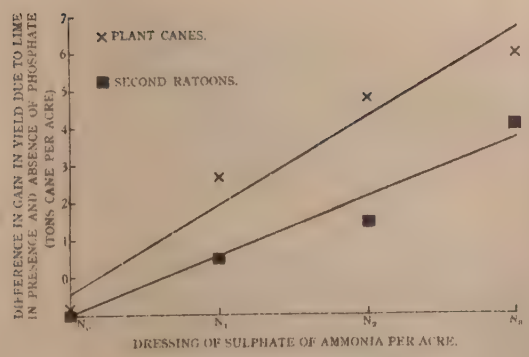

FIG. IV.—EFFECT OF PHOSPHATE ON GAIN IN YIELD DUE TO LIME IN THE PRESENCE OF INCREASING DRESSINGS OF NITROGEN. (THE INTERACTION OF LIME WITH NITROGEN AND PHOSPHATE)

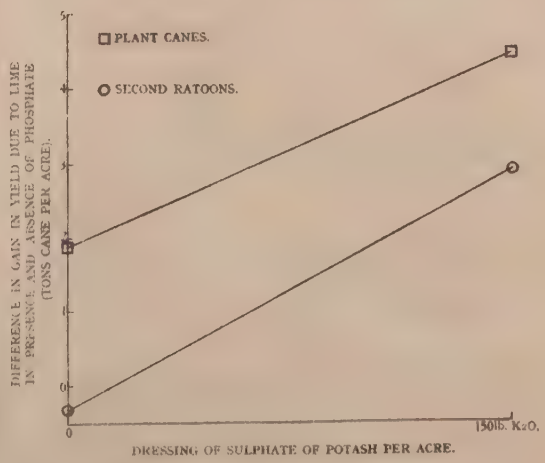

FIG. V.—EFFECT OF PHOSPHATE ON GAIN IN YIELD DUE TO LIME IN THE PRESENCE AND ABSENCE OF POTASH. (THE INTERACTION OF LIME WITH PHOSPHATE AND POTASH).

TABLE VIII.—*Gains in yield due to lime in presence and absence of potash. (The interaction of lime with potash).*

YIELDS OF CANE IN TONS PER ACRE.

Plant Canes (1930-32).

Dressing of ground limestone in 1930.	DRESSING OF SULPHATE OF POTASH IN 1930.	
	Nil	150 lb. K_2O per acre.
10 tons per acre ..	39.10	39.91
Nil	30.72	32.18
Gain due to lime	8.38	7.73

Second Ratoons (1933-34).

Dressing of ground limestone in 1930.	DRESSING OF SULPHATE OF POTASH IN 1933.	
	Nil	150 lb. K_2O per acre.
10 tons per acre ..	23.26	25.24
Nil	17.13	19.17
Gain due to lime	6.13	6.07

Interactions of Lime with Potash and Phosphate.

THE INTERACTION OF LIME WITH POTASH.

The average effect of potash on the gains in yield of plant canes and ratoons due to lime is recorded in Table VIII.

If the plot treatment with phosphate is not taken into account, lime gives no greater gain in yield of plant canes and ratoons in the presence than in the absence of potash on the experimental area, *i.e.* the first order interaction of lime with potash is not significant for either crop.

Potash gave an average increase in yield of plant canes of 1.13 tons of cane to the acre which cannot be established as significant. It gave an average increase of 2.01 tons to the acre of second ratoons which might be due to chance far less than once in 100 times.

TABLE IX.—*Effect of potash in presence and absence of phosphate, on gain in yield due to lime. (The interaction of lime with potash and phosphate).*

GAINS IN YIELD DUE TO LIMESTONE.

Plant Canes (1930-32).

Dressing in 1930 of superphosphate	DRESSING OF SULPHATE OF POTASH PER ACRE IN 1930.	
	Nil	150 lb. K_2O
150 lb. P_2O_5 per acre	9.31	9.95
Nil	7.42	5.51
Diff. in gain in yield due to lime	+1.89	+4.44

Second Ratoons (1933-34).

Dressing in 1933 of superphosphate	DRESSING OF SULPHATE OF POTASH PER ACRE IN 1933.	
	Nil	150 lb. K_2O
150 lb. P_2O_5 per acre	5.97	7.51
Nil	6.30	4.63
Diff. in gain in yield due to lime	−0.33	+2.88

THE INTERACTION OF LIME WITH PHOSPHATE AND POTASH.

The effect of phosphate on the gain in yield of plant and ratoon canes due to lime in the presence and absence of potash is recorded in Table IX.

Plant Canes (1930-32).—In the absence of potash the favourable effect of phosphate on the gain in yield due to lime is 1.89 tons of cane to the acre. In the presence of potash the favourable effect of phosphate on the gain in yield due to lime increases to 4.44 tons of cane to the acre. The interaction of lime with phosphate and potash cannot be established as statistically significant for the plant canes.

Second Ratoons (1933-34).—In the absence of potash the average effect of phosphate on the gain in yield due to lime is negligible. In the presence of potash, phosphate increases the gain in yield by 2.88 tons of cane to the acre. The interaction of lime with phosphate and potash for the second ratoons might be due to chance between once in 20 and once in 100 times.

It will be recollected that the second ratoons (but not the plant canes) gave a small but significant average response in yield to potash.

TABLE X.—*Effect of size of dressing of nitrogen, in presence and absence of potash, on gain in yield due to lime. (The interaction of lime with nitrogen and potash).*

GAINS IN YIELD DUE TO LIMESTONE.

Plant Canes (1930-32).

Dressing in 1930 of sulphate of potash	Dressing of S/A per Acre in 1930.	
	Less than 90 lb. N.	Over 90 lb. N.
10 lb. K_2O per acre	8.78	4.60
Nil	9.03	6.43
Diff. in gain in yield due to lime	−0.25	−1.83

Second Ratoons (1933-34).

Dressing in 1933 of sulphate of potash	Dressing of S/A per Acre in 1933.	
	Less than 90 lb. N.	Over 90 lb. N.
150 lb. K_2O per acre	7.20	4.94
Nil	7.53	4.74
Diff. in gain in yield due to lime	−0.33	+0.20

TABLE XI.—*Effects of nitrogen, phosphate and potash on gain in yield due to lime.*

GAINS IN YIELD DUE TO LIMESTONE.

Plant Canes (1930-32).

Treatment with phosphate and potash.	Dressing of Sulphate of Ammonia Per Acre.	
	Less than 90 lb. N.	Over 90 lb. N.
Phosphate and potash	10.88	7.16
Phosphate alone	9.14	9.85
Potash alone	6.67	2.04
Nil	8.90	3.00

Second Ratoons (1933-34).

Treatment with phosphate and potash.	Dressing of Sulphate of Ammonia Per Acre.	
	Less than 90 lb. N.	Over 90 lb. N.
Phosphate and potash	8.00	7.02
Phosphate alone	6.45	5.50
Potash alone	6.38	2.87
Nil	8.61	3.98

The experimental area is therefore on the average definitely deficient in potash as far as the second ratoons are concerned. *On the potash-deficient area it appears that the maximum beneficial effect of phosphate on the gain in yield due to lime is not realised unless a dressing of potash also is applied* (Figure V).

Interaction of Lime with Nitrogen and Potash.

It has been shown that the fall-off in the gain in yield due to lime, which occurs in the presence of high nitrogen, can be counteracted by treatment with phosphate (Table VI.) The effect of potash under similar conditions is recorded in Table X.

The information obtained from Tables III and VI indicates that the effect of sulphate of ammonia on the gain in yield due to lime becomes of major importance when the dressing exceeds 80 to 100 lb. of nitrogen to the acre. In Table X the yield data for dressings of nitrogen less than 90 lb. to the acre are pooled, as are the yield data for larger dressings. Pooling the data in this manner enables a more accurate comparison of the relative effect of potash in the presence of high and low nitrogen.

According to the data set out in Table X *a dressing of potash as heavy as 150 lb. K_2O to the acre does not counteract the adverse effect of high nitrogen on the gain in yield of plant ratoon canes due to lime on the experimental area. It appears therefore that the manures phosphate and potash differ fundamentally in regard to their effect on the interaction of lime with nitrogen.*

Summary of the Interactions.

The effects of nitrogen, phosphate and potash on the gain in yield of plant canes and ratoons, due to lime, are set out in Table XI.

The data in Table XI epitomize four of the important principles which have been established by means of Experiment III, namely:—

(1) *The gain in yield of plant canes and ratoons due to a dressing of lime equal to the lime requirement, can fall off very seriously when sulphate of ammonia is added in amounts which exceed 80 to 100 lb. of nitrogen to the acre.*

Similarly the gain in yield due to sulphate of ammonia can be significantly diminished in the presence of lime.

(2) *This diminution in the beneficial effect of lime (and of sulphate of ammonia) can be counteracted by the addition of phosphate.*

(3) *This diminution in the beneficial effect of lime is not counteracted by the use of potash, in the absence of phosphate, on the area under experiment.*

(4) *Under conditions of potash deficiency (as with the second ratoons) the gain in yield due to lime can be increased by dressings of potash, provided that adequate phosphate is present.*

Appendix I.

Analysis of Yield Data for Experiment III.

The design of Experiment III is such that all treatments are not repeated an equal number of times in all six blocks. Consequently some of the degrees of freedom associated with treatments are entangled with the degrees of freedom associated with blocks. It will be seen from an inspection of the layout (Figure I) that the only set of degrees of freedom for treatments entangled in this manner is that concerned with the third order interaction Ca × N × P × K. The treatment totals for the remaining 14 sets of degrees of freedom (Ca, N, . . . , Ca×P×K, N×P×K) are derived from equal numbers of plots in each block, and therefore are orthogonal with the blocks.

The mode of combination of the treatments in Experiment III is such that when any one series of 16 treatments is fixed, the 16 treatments in each of the five remaining series are also fixed.

The effect of laying out the experiment in "half blocks," in the manner which has been described, results in a relative loss of information in the estimation of the third order interaction Ca×N×P×K, which is based on two-thirds of the number of plots, in comparison with the estimations of the other interactions, which are based on all plots.

Analysis of Variance of Yield Data for Second Ratoon-Canes.
(*The yield data for the individual plots are recorded in Figure I*).

Due to	D.F.	Sum of squares.	Mean square.	$\frac{1}{2}\log_e$.	Diff. in $\frac{1}{2}\log_e$.
Blocks	5	21,378.43	4,275.69	—	—
Treatments	(31)	(281,022.16)	9,065.23	2.2536	1.5060*
Ca	1	95,571.26	95,571.26	3.4312	2.6836*
N	3	150,236.61	50,078.87	3.1081	2.3605*
P	1	1,060.01	1,060.01	1.1805	0.4329
K	1	8,874.26	8,874.26	2.2429	1.4953*
Ca×N	3	6,555.62	2,185.21	1.5422	0.7946*
Ca×P	1	1,935.01	1,935.01	1.4814	0.7338†
Ca×K	1	133.01	133.01	—	—
N×P	3	113.87	37.96	—	—
N×K	(3)	(3,312.62)	1,104.21	1.2008	—
$[(N_0+N_1)$ v $(N_2+N_3)]$ K	1	2,741.35	2,741.35	1.6556	0.9080†
(N_0+N_1) K ..	1	567.19	567.19	—	—
(N_2+N_3) K ...	1	4.08	4.08	—	—
P×K	1	225.09	225.09	—	—
Ca×N×P	(3)	(4,337.53)	1,445.84	1.3357	0.5881†
Regression ...	1	3,915.92	3,915.92	1.8338	1.0862*
Deviations ...	2	421.61	210.81	—	—
Ca×N×K	3	2,338.87	779.62	1.0268	—
Ca×P×K ..	1	2,741.34	2,741.34	1.6556	0.9080†
N×P×K	3	1,885.79	628.60	0.9192	—
Ca×N×P×K ...	3	1,701.28	567.09	—	—
Error	59	26,315.16	446.04	0.7476	—
Total	95	328,716.74	—	—	—

Table of Significance.

n_1	n_2	P=0.01	P=0.05
3	60	0.7086	0.5073
1	60	0.9784	0.6933

* Due to chance less than once in 100 times. † Due to chance less than once in 20 times.

(*To be Continued.*)

REVIEWS.

GARDEN BOOK OF BARBADOS.

Department of Science and Agriculture, Barbados, 1935, pp. 154, 3*s*.

The foreword to this admirable publication states that its object is to bring before the public of Barbados, and visitors to the Island, the wealth of beautiful plants which succeed under Barbados conditions and to encourage a more widespread interest in the suitable cultivation of such plants. The success or otherwise of gardening ventures is largely predetermined by knowing what to grow as well as how to grow it. The abundance of material suitable for temperate gardens is kept before the public by displays in parks and nurseries, by shows and exhibitions and by seedmen's catalogues. To the gardener in the West Indies, and doubtless to many other tropical gardeners, such opportunities are strictly limited, and a selection of material suitable for local conditions such as are given in the Garden Book is exceedingly welcome.

The first chapter of the book is entitled "A note on the climate of Barbados" and is presumably intended for visitors. The next two chapters deal with "Soils and manures" and "Insect pests and diseases of gardens" respectively. The first of these contains a brief outline of the function of the essential mineral elements in plant nutrition, and recommendations for maintaining the soil in a fertile condition, based on the results of soil analyses. That section of the third chapter, dealing with the control of insect pests, gives an excellent account of such matters and should be of great interest to all amateur gardeners. The section on the control of fungus diseases might conceivably have been extended with advantage; if only to emphasise the importance of such control. The commercial gardener and to an increasing extent, the amateur gardener of temperate countries relies on a routine spraying programme for the prevention of disease, but in the West Indies, so far as the reviewer is aware, spraying is resorted to only after disease has made its appearance.

The following chapters contain lists of plants suited to Barbados conditions classified under the following heads: Ornamental Trees (chap. 4), Ornamental Plants (chap. 5), Herbaceous Garden Plants (chap. 6), Ornamental Climbing Plants (chap. 7), The Fernery and Some Fernery Plants (chap. 8), Miscellaneous Ornamental Plants, Lawns (chap. 9), Palms (chap. 10), Plants suitable for Particular Purposes (chap. 11), Plants bearing Edible Fruits (chap. 12), and The Vegetable Garden (chap. 13).

A brief description is given of each plant listed, with indications of suitable conditions for growth and the method of propagation. Keys are provided for the identification of the ornamental trees described in the book, a factor which will no doubt be of great help to visitors. For the gardener, charts are provided showing the time of flowering of ornamental trees and garden plants and for vegetable cultivation. The latter gives details as to suitable varieties, source of seed or planting material, time of planting, method of planting, method of manuring and duration of crop. No claim is made that all the successful ornamental plants and vegetables are included in these lists; the inclusion of any such omitted from the book is to be left for later editions. The outstanding feature of the book is its clarity. Too often information concerning West Indian plants is available only after long search, but the systems of classification used in the present book should make information concerning the identification and cultivation of the commoner garden plants easily obtainable. Although primarily intended for Barbados, on these grounds it should have a much wider appeal, and particularly so in neighbouring West Indian Islands. The book is well printed and bound in stiff covers, and at 3*s*. is very good value. It is to be hoped that the success of this first edition will soon merit further enlarged editions. The Department of Science and Agriculture in Barbados and all who assisted in the compilation of this book are to be congratulated on the success of their efforts.

E. P.

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BIOLOGICAL PROCESSES IN TROPICAL SOILS.

By A. Steven Corbet, B.Sc., Ph.D., F.I.C., *W. Heffer & Sons*, Cambridge, 1935, pp. 156, price 7*s*. 6*d*.

The inorganic constituents of soils have been investigated in great detail, and are now fairly well understood—the organic transformations are still referred to in vague and well-worn phrases. One reason for the lack of knowledge of the organic constituents of the soil is that the factors involved are mainly biological, and purely chemical methods are restricted in their use. Dr. Corbet has the advantage of being both chemist and microbiologist, and this dual interest has given unusual clarity to a difficult piece of work. In the preface he explains that the book was written primarily for agricultural chemists working in tropical countries, and this purpose has been achieved to the full.

The author has wisely confined his observations mainly to Malaysia, where his experience as Bacteriologist to the Rubber Research Institute has given him the voice of authority, and yet the fact that Malaysia is typical of many parts of the tropics justifies the general title of the book. A point of prime importance which is emphasised throughout is the application of Jenny's Law to tropical soils; and a soil temperature of 25°C. is shown to be the critical point, above which

accumulation of organic matter cannot take place. Dr. Corbet has applied this to the nitrogen cycle, and has pointed out that it is useless to attempt to obtain a permanent increase in soil nitrogen in a cleared area where the effect of removing the forest cover has been to raise the soil temperature above this critical point. This is of the utmost importance in many tropical crops, since it means that frequent light applications of nitrogenous fertilisers constitute the most economical method of raising the nitrogen status of the plants.

Agricultural chemists will find this book of the greatest interest and value. Planters will find that the method of treatment is not too specialised and detailed, and many points of practical value are included. Botanists and entomologists will find interesting descriptions of the ecology of Malaysia.

D. W. D.

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PROBLEMS IN SOIL MICROBIOLOGY.

By D. W. Cutler and L. M. Crump. *Longmans, Green & Co.*, London 1935. pp. 104. 9s.

As explained in the preface the book incorporates the substance of a series of lectures delivered by one of the authors (D.W.C.) at the University College of Wales, Aberystwyth, on the Aberystwyth Lectures Foundation during the session 1934-35. Moreover, the contents are largely based on the research work which has been carried out in the General Microbiology Department of the Rothamsted Experimental Station by the authors and their colleagues, and stress is laid on the fact that the volume is not a text-book of soil microbiology.

In their lucid exposition of the problems which are dealt with in this book, the authors introduce the reader to the several different kinds of organisms which inhabit the soil world; and, moreover, they show that the activities of these soil-dwellers largely depend upon those other plants and animals for which the soil serves as a habitat. For the sake of convenience and safety, research workers aim to elucidate the influence of single factors when investigating a complex problem and this is the line advocated by the authors of this book. There are many such single-factor problems in soil and when the physiology of the various organisms (plant and animals) is better understood the major task of studying the interaction of these several organisms upon inanimate chemical substances and upon each other under ever-varying conditions of moisture and temperature presents a programme of truly fundamental research to occupy many workers for centuries to come. Much of what is now known of soils is based on empirical research for which the fundamental explanation will come later as the result of the solution of such problems as are discussed in this stimulating and useful contribution to our knowledge of what is living in the soil world.

H. R. B-J.

THE ARACHNIDA.

By Theodore H. Savory, M.A., *Edward Arnold & Co.* London, 1935, pp. 218, 8 plates. 25s.

The author in his preface says that his purpose in writing this book is to give to Arachnology something of the unity and status of an individual science that is possessed by Entomology. He certainly achieves this object in what must be one of the first books written along these lines.

Spiders and mites have received a fair amount of attention in scientific literature, but the remaining eight orders are here introduced for the first time in a readily readable form.

The author treats his subject mainly from a morphological aspect, and it is to be regretted that there is not more in the book on the biology of the organisms dealt with, but this only emphasises the lack of information on this subject.

The keys to the main divisions in each order should prove extremely useful to any one wishing to place the more obscure forms in their correct families, and it is to be hoped that this will be a stimulus to further study of these animals.

The chapter on Economic Arachnology though brief, forms a good introduction to the many economic problems connected with this class, and with the chapter on the strange parasite Linguatulids is to be especially recommended to the practical worker.

The book is illustrated throughout with the most excellent figures, though it is a pity that the magnification of these is not stated.

A comprehensive bibliography forms a most valuable addition to a book that can be strongly recommended to the attention of both Entomologists and others wishing to know more about this neglected class.

D. V. F.

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SUPPLY AND DISTRIBUTION of the Various Types of Indian Cotton during the Season of 1933-34. *Statistical Bulletin*, No. 4 (1933-34), Bombay *Indian Central Cotton Committee*, pp. 18, 1935, price 8 annas.

This bulletin marks the completion of the first successful attempt to take stock of the production and distribution of Indian Cotton over a period of one year (1933-34). The great range of conditions and of varieties which together determine India's cotton crop have necessitated in the absence of a State controlled system of collection of representative samples as in the U.S.A., a classification by varieties and tracts. The production data are compiled from the crop forecasts issued by the Government, while the distribution data are compiled from voluntary returns furnished by exporters, mills and the trade. A further difficulty is that of estimating

the home (*i.e.* outside the mills) consumption of unginned cotton which is believed to account for as much as 15 per cent. of the total production.

This is an interesting publication which will doubtless become of increasing value as the statistics for future years are improved. It should be of considerable help in many domestic problems such as adjusting the supply to the requirements of the Indian mill industry in the matter of different staples, but it should also be an increasing help to Indian export trade in that it should make possible some control of the designation of export cottons.

E. P.

THE METAMORPHOSIS OF PAPER.

One of the results of the application of scientific methods to the cellulose industries, and in particular to paper, has been a realisation of the considerable inherent strength of the unit fibre. One would, of course, hesitate to select paper for any purpose for which great strength is essential, but at the same time it must be remembered that, when paper is broken, it is usually the bonds connecting the fibres, and not the fibres themselves, which are ruptured. Reliable figures are necessarily difficult to obtain, but actual measurements indicate that, weight for weight, the tensile strengths of certain cellulose fibres and of wires made from light metals are of the same order (cf. *Nature*, 131, 553, April 15, 1933).

It is not unnatural, therefore, that many attempts have been made to produce paper products having the equivalent strength and durability of more resistant materials such as cloth, leather, wood and even metal, and in such cases attention has usually been concentrated on strengthening the bonds between the fibres both laterally and longitudinally, on the reasonable assumption that the individual fibres can take care of themselves. By selecting the strongest of fibres and treating them mechanically in the paper-mill beater, it is possible to split the ends of the fibres into smaller fibrillae which intertwine on the paper-machine and develop considerable strength, but there is obviously a limit to the extent to which this can be carried, and this limit precludes paper completely as a competitor even to a woven fabric.

The most promising results have been obtained by processes of impregnation, in which the fibres are held together by addition of an independent consolidating material. Thus, if paper is passed through zinc chloride or sulphuric acid under controlled conditions of concentration and temperature, the cellulose is modified in such a way as to form a hard impervious surface layer. This so-called 'vulcanising' process not only imparts a certain amount of strength and solidity to the sheet, but also, if a laminated product is made by pressing sheets into intimate contact before the hardening process is complete, a hard material having many of the properties of wood is obtained. Material of this type, for example, fibrous plasters, mixtures of paper and glue, and laminated paper products made by impregnation with synthetic resins, have been available for many years, but have not hitherto been obtainable in the form of a strong flexible sheet.

The methods suggested for strengthening fibres by simple immersion in a bath occupy a share of the patent literature far out of proportion with the value of the material they produce. There are, however, several outstanding exceptions, one of which is rubber. Absorbent paper containing more than 90 per cent. of α-cellulose can be heavily impregnated with rubber either as a latex suspension or dissolved in a solvent, and the resulting product, when suitably coloured, finished and embossed is an excellent imitation of leather or cloth, from the point of view not only of appearance but also of strength and durability.

Another very successful product, but of a rather different character is "Linson", which is described as a cellulose fabric. This gives a partial clue to its identity, although the base material is manilla, which is one of the strongest vegetable fibres known. The great strength of Linson is indicated by the fact that the folding-resistance is almost ten times that of an ordinary bookbinding cloth. The difficulty of producing a high-glazed, water-repellent finish without brittleness seems to have been overcome, and not only is it possible to scour or polish the surface without damage or removal of colour, but also the resistance to oil and petrol gives it a considerable advantage over the numerous cellulose lacquers at present available for waterproofing. Resistance to water is usually and for obvious reasons incompatible with suitability for work with adhesives, but Linson must be ranked with the few products of its kind which fulfil both requirements satisfactorily. Apart from alkalis, fairly strong acids and certain organic solvents (which may be regarded as unfairly stringent tests) we have found only one medium which it will not resist without change, and that is hot water; the effect of storage and weathering have, however, yet to be tested.

Numerous uses for this class of material at once suggest themselves, but mention may be made here of all kinds of substitutes for the poorer and thinner varieties of leather, for bookbinding material, motor-car roofings, desk-tops and (since it can be sewn, washed, ironed and blocked) even for clothes.—(*Nature*, Vol. CXXXIV, No. 3,398, pp. 921-22, 1934.)

J. G.

THE EDITOR requests that any subscriber who fails to receive *Tropical Agriculture* regularly should communicate with him immediately in order that the matter may be rectified.

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

Cane Syrup Manufacture.—*T. B. McClelland.*

Juices of the cane varieties tested ranged in colour (after filtration through cotton) from olive through greyish to a pronounced dark green; from light to dark the order was: SC 12/4, PR 803, M 42, POJ 2725, M 28, FC 916, M49, POJ 2878 and FC 998—the latter two very dark. Treatment with lime alone or in conjunction with phosphoric acid gave an almost brilliant juice, which darkened on subsequent boiling with some loss of flavour. Extract of maguey leaves, or of cassia, especially the latter had remarkable clarifying properties, but gave a precipitate hard to filter. Of all the methods tried, filtration through "Filter-cel" gave the clearest product the next clearest being obtained with ferric salts. The colour of the juice is generally darker after filtration and boiling, especially if the reaction is alkaline. A slight acidification with tartaric acid lightens the colour to a golden yellow or a light brown. Boiling and concentration have the most influence on the colour and quality of the syrup. The best flavoured syrups were those that had been filtered only with "Filter-cel"; those from juices that had been partly fermented were second. Mayaguez-42 ranked first in flavour, with FC 998 and BH 10 (12) close seconds. The lightest coloured syrups were those from juices that had been partly fermented, except those that had been treated with active carbons, which however, adversely affect the flavour. Crystallization may be prevented by inverting part of the sucrose with invertase, or by fermenting the juice prior to filtration with a pure culture of yeast for five or six hours. This also lightens the colour and makes filtration easier, but slightly deteriorates the flavour. To prevent mould and further darkening on storage, the bottles or cans containing the finished syrup should be filled completely and kept tightly closed. (*Int. Sugar Jr.* Vol. XXXVII, No. 441, pp. 361-2, 1935).

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Cane Ripeness Meter—*Alex. Gordon.*

It is called the "Electrynx" and is a microammeter, but arbitrary markings from 0 to 100 are set on the scale, which is not in m/amps. It is provided with iron (—) and copper (+) electrodes. A "starting-fork" is used to punch the holes in the cane stalk to a certain depth, say about half an inch, to make way for the electrodes of the "Electrynx". Readings are taken immediately the electrodes are inserted and the pointer of the dial has come to rest. This was found necessary because it was found that there is a certain polarizing effect around the + electrode, thus causing bubbles to form, and the readings to decrease. However, encouraging results were obtained with this apparatus in estimating the ripeness of cane in the field. Ten representative samples of cane from a lot of 0.05 hectare were chosen, and two readings taken of each stalk, the average of ten duplicate readings being paired with the laboratory analyses of the crusher juices from the mill of the same lot, the results being given in the following table:—

Scale Readings.	Brix.	Polarization.	Purity.	Piculs Sugar, per ton cane.
53.01	18.88	16.46	86.80	1.91
58.38	18.47	15.91	85.70	1.83
62.93	18.24	15.64	85.15	1.78
67.20	18.64	16.45	88.02	1.93
72.61	18.71	16.54	88.23	1.95
77.60	18.01	16.10	88.92	1.91
82.24	18.04	15.93	88.02	1.87
86.95	18.09	15.84	87.18	1.85
92.02	17.13	14.76	85.74	1.69
95.68	17.13	14.73	85.90	1.69

It is thus seen that for the short range of 17.13 to 18.88 for the Brix there is the wide range of 53.01 to 95.68 for the meter readings, thus permitting of a much greater accuracy of reading than with the hand refractometer. Moreover, the evaporation error present in the latter method is eliminated; while the readings can be obtained very rapidly, and by an unskilled person. An improvement which suggests itself is that if instead of having the starting fork and the meter separate, the electrodes were used as the tynes of the fork with the meter mounted on the device it would be a much more practicable apparatus. A direct reading could be obtained immediately as soon as the holes are penetrated. A table could be worked out by the planter to suit his conditions, or it would be better to colour the scale of the meter into divisions, so that the operator could tell at a glance from the reading the condition of the growing cane, thus:—

Meter Readings.	Scale Colouring	Remarks.
0 to 20°	Green	Cane unripe.
20 to 40°	Greenish-orange	Cane nearly ripe
40 to 75°	Orange	Cane ripe
75 to 90°	Red	Cane passing ripeness
90 to 100°	Brown	Cane rapidly passing ripeness.

—(*Int. Sugar Jr.* Vol. XXXVII, No. 441, 1935, p. 357.).

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Avocado Oil.

Preparation and Properties.—For centuries, vegetable oil was used as a basis of all cosmetics. In particular, the native women of Mexico and South America used avocado oil as a protection for the skin against drying winds. Mineral oils have probably been used in recent years because of their keeping quality, but the continued use of creams containing only mineral oils and mineral waxes is apt to irritate the skin tissues. The cosmetic chemist of today is endeavouring to incorporate an easily assimilated form of organic salts, vitamins and skin food materials in his cosmetics. He is aiming at giving the public a merchandise of merit and in this respect he is paying particular attention to avocado oil.

The avocado, botanically named *Persea gratissima* is a member of the laurel family, and is a native of tropical America, being recorded as early as 1513 by New World explorers. The Californian avocado is especially adapted for the soil of that country; it has been produced from the Nicaraguan, Mexico and South American varieties by cross-pollination, grafting and budding. "Calavo" is the copyright name of the highest grade of avocado put out by the Calavo growers of California, a non-profit growers' marketing organisation, the fruit having been rigidly tested with regard to flavour, oil content, nutritive value and keeping quality.

Methods of Manufacture.—The modern method of manufacturing avodaco oil is an elaborate adaptation of the simple process used by the ancient Guatemalans. Fruit of the Calavo type is used which has passed all the standard requirements of first-grade fruit except that it has exterior blemishes and is therefore unsuitable for marketing as fresh fruit. After having softened to the edible stage, the fruit is peeled and the seed removed. The flesh is then cut into strips and placed in a tray where the water content (68 per cent. to 83 per cent.) is removed in an atmosphere of either nitrogen or carbon dioxide at 130° F. The dehydrated pulp, composed of solid fibrous matter (2 per cent. to 7 per cent.) and oil (10 per cent. to 30 per cent.) is then dropped on to a strip of cotton in a cake mould and when the cake has formed, it is removed by means of a sheet of steel, which is slipped underneath, to the lowest frame of a steel box hydraulic press. The sheet steel is then withdrawn and the next frame fitted in the same manner. When all the frames are charged, a pressure of from 3,000 to 4,000 lb. per square inch is exerted and a piston forces the frames upwards one against another. The oil which is squeezed through flows over the sides of the press into a galley around the bottom frame and then out into a tank, where the fine meal content is allowed to settle. The clear oil is withdrawn and refined by passage through a filter press, the result being a brilliant, clear oil.

Avocado oil is rich in the oil-soluble vitamins, A, D and E, phytosterol and lecithin. Phytosterol is isomeric with cholesterol, the active principle in lanoline which plays the major role in the so-called absorption of nourishing and cold creams. Avocado is hence one of the most penetrating oils that is known, and is of value in all kinds of cosmetic creams, serving as a carrier for other valuable substances which lack penetratrating power. Lecithin is perhaps the most important of the lipoids used in medicine, and although as yet little is known about its therapeutic value in cosmetics, it is known to assist materially in the oxidation of fatty acids, the physico-chemical stabilisation of the blood stream and in the permeability of the cell wall. The vitamin D content of avocado oil is of particular interest to the cosmetician who fully realises the value of an oil containing this vitamin.

Any cosmetic formula in which oil is an ingredient can be adapted to avocado oil, but trials should first be made, since it produces a stiffer emulsion than mineral oils. As sold for cosmetic purposes, the oil has not been "winter processed" and hence deposits stearin, when cooled to about the temperature of household refrigeration.

It is a non-drying oil and is claimed to have an excellent keeping quality. Laboratory tests have shown that when several samples of the residual oil were kept in partly filled bottles for a year, there was only a slight increase in free fatty acid and some samples, kept at 40° F. for twelve years, also showed only a slight Kreiss test for rancidity.

Avocado oil can be spoken of as a "sunshine oil" owing to its vitamin D content. The cosmetician is particularly interested in the possibilities of an oil containing this vitamin.—(*Pharmaceuticals & Cosmetics*, July, 1935, p. 73.)

* * *

Nitric Acid Process for Recovery of Cellulose from Bagasse.

A high-grade cellulose pulp can be produced from bagasse by the following treatment: digest for one hour at 90°—100°C with two per cent. nitric acid: drain, wash, and recover nitric acid: boil 45 minutes with two per cent. caustic soda: drain, wash, and recover unused caustic soda: bleach: digest for 30 minutes in five per cent. caustic soda. The percentage composition of such pulp is as follows: pulp recovery 32 to 33: alpha-cellulose 93 to 96: soda-soluble 6.0 to 8.0 ash, less than 0.3. The chemical costs for the process are estimated at less than $10.00 per ton of pulp, a figure much lower than any other nitric acid pulping procedure. The process has further advantages of greater applicability to large scale production. (*Ind. & Eng. Chem.* Vol. XXVI. p. 1339, 1934.)

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Markets have ranged as follows (c.i.f. per cwt.):

	Foreign.		*Preferential.*	
	s.	*d.*	*s.*	*d.*
29th August ...	4	3	8	0
5th September ...	4	3¾	8	0¾
12th September ..	4	3	8	0
19th September ..	4	4½	8	1½
26th September ...	4	6	8	3
3rd October ..	4	9	8	6
10th October ..	4	9¾	8	6⅛
(*11th October*, 1934) ...	4	5¼	8	4½

After a quiet and very inactive tone, the market has again improved, with more business passing. This has been due to steadier and larger demands for various descriptions of direct consumption sugars by home grown and refining interests. More recently there has been a further improvement in values which is assigned to the somewhat uncertain political situation and to the possibility of serious complications arising out of this situation.

* * *

COFFEE.—A large quantity (about 250 barrels) of Blue Mountain Jamaica was offered at auction on the 3rd Sept., but only a small proportion sold. Bold size fetched up to 187*s.* and second size up to 176*s.*—(*West India Committee Circular*, 12th September, 1935.)

* * *

GRAPEFRUIT.—The imports into the United Kingdom for the fortnight ended 24th August, amounted to 36,780 cwt. consigned by the following countries: Jamaica, 18; South Africa, 19,496; United States, 10,992; Brazil, 3,514; and other countries 2,760. — (*West India Committee Circular*, 12th September, 1935.)

* * *

RUBBER.—Quotations for Plantation Sheet have ranged as follows:—

	Pence per lb.
28th August ...	5 5-8
4th September	5 9-16
11th September	5 9-16
18th September	5 3-8
25th September	5 11-16
2nd October ...	5 11-16
9th October ...	6
(*10th October*, 1934)	7

The unfavourable political outlook and fears of a devaluation of the Dutch guilder, coupled with some pessimism regarding the outcome of the meeting of the International Rubber Regulation Committee on 24th September, exerted a depressing effect upon the market. Prices have since, however, recovered. According to the American Questionnaire, August consumption was estimated at 39,242 tons and total consumption for the first eight months of 1935 at 331,440 tons compared to 322,794 tons in 1934.

COTTON. The following are the official spot prices in pence per lb. of the Liverpool Cotton Association:—

	American Mid.	*Egyptian F.G.F. Sakel.*
30th August ..	6.21	7.95
6th September ...	6.11	8.13
13th September ..	6.17	8.11
20th September ..	6.53	8.42
27th September ...	6.40	8.52
4th October ...	6.53	—
11th October ...	6.50	—
(*12th October*, 1934) ...	6.96	8.10

After a period of comparative steadiness in raw cotton prices, quotations more recently have advanced owing to extensive covering by Bombay and Continental interests. There has been a scarcity of contracts in Liverpool and with practically no selling operations, prices stiffened. It is generally expected that an outbreak of hostilities by a European power would cause prices to rise. There is practically no stock of West Indian Sea Island Cotton in Liverpool. The latest prices, however, at 15*d.* to 18*d.* per lb. continue firm.

* * *

BANANAS.—Jamaicas are in poor demand and the price has declined by £2 per ton to £16 5*s.* delivered London and £16 nearest station. The imports into the United Kingdom for the fortnight ended August 24th amounted to 1,032,391 bunches, consigned by the following countries: Jamaica, 850,183; Gold Coast, 400; Canary Islands, 17,322; Brazil, 95,888; Madeira, 24; and Honduras 68,574. — (*West India Committee Circular*, 12th September, 1935.)

* * *

COCOA.—During the past month the market has been slightly better and advices from New York state that the "manufacturing end of the trade is exceptionally busy, and in some directions working 24 hours a day". African growths have met with steady trade and prices are slightly dearer. F. F. Accra is quoted at 23*s.* 9*d.*, Cameroons at 25*s.* and locally the price is $6.25 per fanega for plantation cocoa.—*By Courtesy of the Cocoa Planters' Association of Trinidad, Ltd.*

* * *

LIME PRODUCTS.—*Lime Oil.*—Handpressed is in small supply. The last arrival sold at 40*s.* per lb. *ex* wharf. Sellers of Distilled are asking 22*s.* 6*d.* per lb. *Lime Juice.*—No interest is being shown by buyers of Concentrated at present. Raw is quiet and unchanged; the last price was 2*s.* to 2*s.* 6*d.* for good to fine.—(*West India Committee Circular*, 12th September, 1935.)